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HYBRID COMPUTER VEHICLE HANDLING PROGRAM

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Final Report

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16. Abstract

This hybrid computer simulation for vehicle handling studies has been in use for four years and has been validated for a large class of two axle vehicles. The following suspensions can be simulated: (1) four wheel independent, (2) independent front and solid rear axle, (3) solid front and rear axles, and (4) any front suspensions with dual tires on a solid rear axle.

Model validation was accomplished using parametric data representative of a 1974 Chevrolet NOVA, 1974 VW Campmobile, 1974 White Tractor and various other automobiles and trucks. Braking, steering and combinations of braking and steering were input to the simulated mathematical model for validation and the simulation time histories were then compared to full scale test data.

This hybrid vehicle handling program can be used for general studies of vehicle dynamics. Performance of the NHTSA standard passenger car vehicle handling test procedures (VHTP's) and calculation of the associated performance comparison variables (PCV) are simulation options. A special interactive user's interface is available to allow program use by vehicle engineers as well as computer specialists.

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METRIC CONVERSION FACTORS

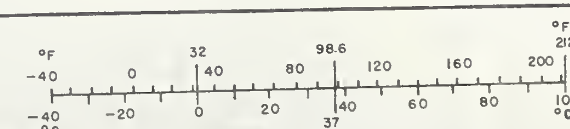
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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SECTION 1
SUMMARY AND INTRODUCTION

This document presents the latest version of the NHTSA Hybrid Computer Vehicle Handling Program (HVHP), which is operational at the Applied Physics Laboratory, Johns Hopkins University. Many refinements have been incorporated into the simulation since the publication of Reference [3]. In particular, heavy or light vehicles of any suspension type can now be simulated, vehicle aerodynamic characteristics are now represented and the tire model has been further refined.

The Applied Physics Laboratory first became involved in the prediction of vehicle dynamic performance via simulation in May of 1972. At that time APL was requested by NHTSA to move to APL an existing vehicle simulation operational on the hybrid computer at the Bendix Research Laboratories [4,5].* NHTSA's motive in moving the simulation was to make it available to all NHTSA contractors for vehicle research. APL reprogrammed the Bendix simulation for its hybrid computer without change of the model and published the result in Reference [2]. The derivation of the original HVHP model is presented in Reference [6].

Work with NHTSA contractors began in July, 1973, when APL started providing simulation service to the Calspan Corporation on the NHTSA research into tire properties' effects on vehicle handling [7]. During the work with Calspan, two primary simulation modifications were completed:

* Numbers in brackets refer to references.

(1) a very flexible user interface for interactive simulation control designed at APL was added by APL

(2) a new tire force and moment model specified by Calspan was added by APL.

Also added to the simulation about this time was the capability to automatically initialize the simulation to perform any of the six Vehicle Handling Test Procedures (VHTP's) and to collect and process the data required to calculate the vehicle performance comparison variables (PCV). These VHTP's and PCV's were originally developed by HSRI (Highway Safety Research Institute, University of Michigan) in References [8] and [9] and restated for computer implementation by APL in Reference [10]. The result of this work was the HVHP (Hybrid Computer Vehicle Handling Program) documented in Reference [3].

The computer program was further extended in 1974 by the Dynamic Science Division of Ultrasystems, Inc. to simulate features of recreational vehicles [14]. These features included aerodynamic effects, solid front axle, dual rear wheels, and four-wheel drive. These program modifications have been implemented and verified with full-scale vehicle testing.

Currently, dynamic performance of vehicles of the following suspension types can be predicted by the HVHP:

(1) independent front and rear,

(2) independent front with solid rear axle,

(3) independent front and solid rear axle with dual rear tires

(4) solid front and rear axles,

(5) solid front and rear axles with dual rear tires.

Validation of each suspension type has been accomplished by comparison of simulation and full scale test data.

In its work with NHTSA contractors, APL has added to the simulation model any refinements required by the contractor to successfully complete his research and the simulation has proven to be economical for vehicle dynamic performance prediction. User experience with the HVHP has shown that while performing parametric runs, 500 seconds of vehicle motion can be simulated in one hour of computer use. This translates to a cost of less than $0.50 per vehicle simulation second and represents a fifty percent utilization of the available computing time. Since this simulation, running at one-fourth of real time, is capable of 900 vehicle simulated seconds per hour, approximately fifty percent of the time is utilized for observing data and changing parameters. The $0.50 per simulated second should be viewed as the current lower cost limit.

For program debugging and model checkout, fewer runs are made in a given time period than when parametric data

are being produced. Therefore, the cost per vehicle simulated second would increase. However, general experience has indicated that on-line data observation for debugging decreases the total time required for program checkout. During the debug phase, HVHP cost usually ranges between one and two dollars per vehicle simulated second, with a decreasing trend toward the $0.50 per second figure.

SECTION 2
HYBRID COMPUTER VEHICLE HANDLING PROGRAM

2.1 INTRODUCTION

Contained in this section is a description of the hybrid computer vehicle handling program. The basic mathematical model is described in terms of seventeen degrees of freedom. The perturbing forces and moments which act on the vehicle are also considered. The simulation implementation and validation are discussed.

2.2 SIMULATION

2.2.1 Mathematical Model

The simulated vehicle is represented by a seventeen-degrees-of-freedom model which consists of:

(1) A basic six-degree-of-freedom model of the vehicle sprung mass.

(2) A two-degree-of-freedom front wheel or front axle model.

(3) A two-degree-of-freedom rear wheels or rear axle model.

(4) A three-degree-of-freedom steering system model.

(5) A four-degree-of-freedom wheel rotational dynamics model.

The six degrees of freedom of the sprung mass model are the six standard translational and rotational degrees of freedom of a body moving in inertial space: translation along three axes and rotation about each axis. The two front wheel degrees of freedom represent the motion of the front unsprung masses. For an independent front suspension the degrees of freedom are the vertical motion of each front wheel. If the front suspension represents a solid axle configuration, the two degrees of freedom are the rotation and vertical motion of the front axle. A corresponding discussion describes the two rear wheel degrees of freedom. An analytical representation of the vehicle model showing independent front and solid rear axle suspensions is illustrated in Figure 1-1.

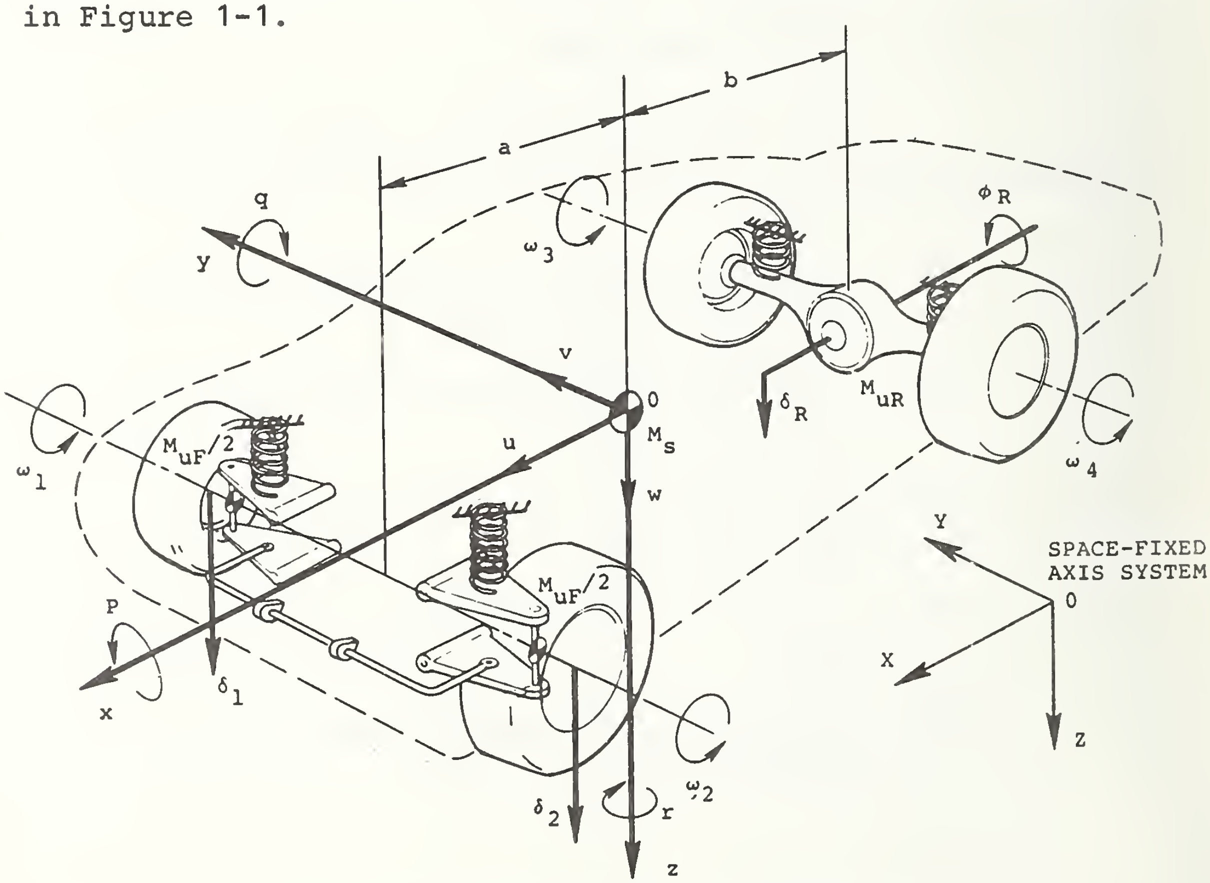


Fig. 1-1 Analytical Representation of the Vehicle Model

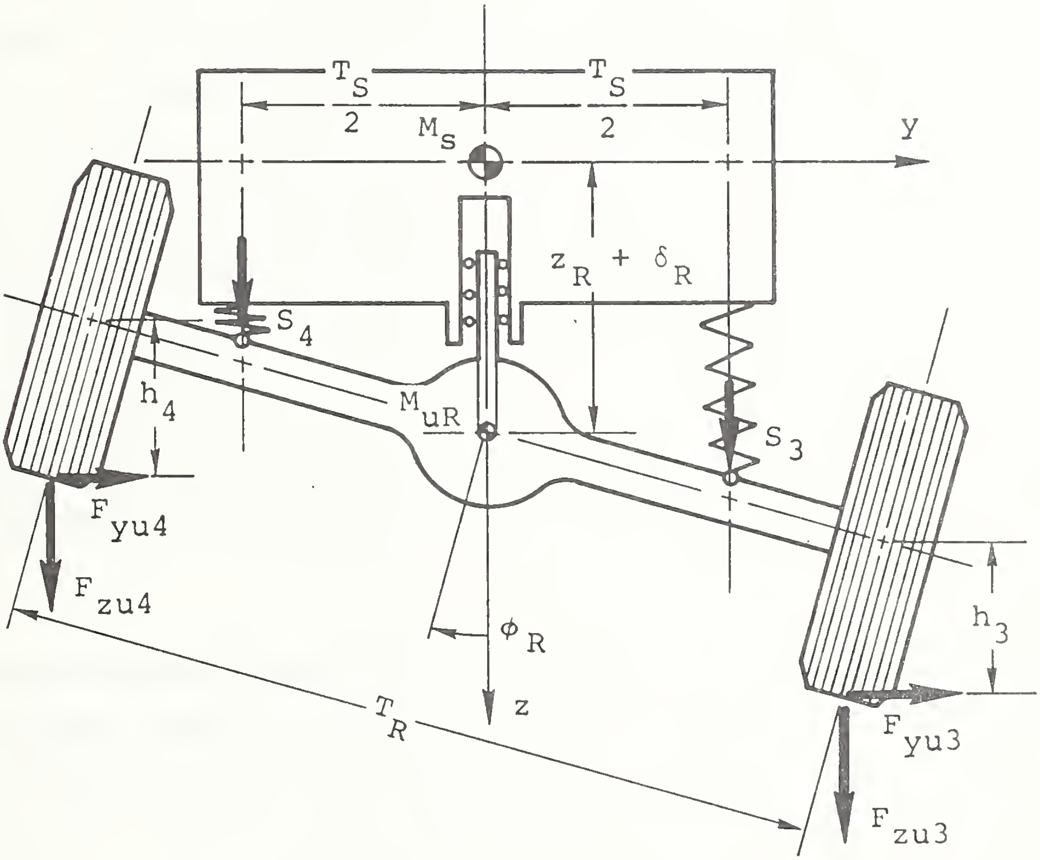


Fig. 1-2 Analytical Representation of the Solid Rear Axle Model

A solid rear axle representation is presented in Figure 1-2.

The vehicle model allows the following options:

(1) independent rear suspension (two rear unsprung masses) with two degrees of freedom corresponding to the vertical motion of each rear wheel.

(2) solid front axle (front unsprung mass) with two degrees of freedom corresponding to the vertical motion and rotation of the front axle.

(3) Dual tires on a solid rear axle with either independent front suspension or solid front axle.

Inertial coupling between the sprung mass and the front and rear unsprung masses is considered but external forces and moments due to rolling resistance and gyroscopic effects of the rotating parts are neglected.

The steering system is represented by a lumped parameter model with three degrees of freedom corresponding to rotational motion of each front wheel about its steering pivot and translational motion of the connecting steering rod and associated mass elements. The effects of steering system friction and compliance are included. The tire moments about

each kingpin axis are functions of the circumferential and side tire forces, tire aligning torque, the inclination and caster of the king pins, and the caster trail effects of the tires. Steering wheel displacement is the steering system input.

Four additional degrees of freedom (for a total of seventeen) are contained in the rotational equations of motion about the spin axis of each wheel. These equations, which include the differential effects of the rear wheels, yield the wheel rotation rates from which slip and, in turn, the circumferential and lateral friction coefficients are computed. The differential equations for wheel rotation are assumed to be isolated from the coupled differential equations of motion of the sprung and unsprung masses, but inertial interaction between the drive wheels is included.

Forces are transmitted between the sprung and unsprung masses through the suspension system. The suspension forces include spring effects, shock absorbers, auxiliary roll stiffness, coulomb friction and "anti" forces such as anti-pitch and antiroll. The suspension deflections are calculated relative to the suspension equilibrium position which varies with vehicle weight. The angular orientation (camber angle, toe angle, caster angle) of an independently suspended wheel, relative to the vehicle body, is specified as a function of the suspension deflection. These functions are input relative to the equilibrium vehicle suspension position and then corrected to the new equilibrium position for varying vehicle weight configurations. Compliance coefficients are used to relate the change in camber angle and steer angle with applied forces and moments at the tire. Provisions are also incorporated to investigate the effects of degraded suspension components.

The force of gravity, aerodynamic forces and moments, and tire forces and moments generated at the tire-road interface are considered the only important externally applied forces and moments acting on the vehicle. The tire forces include the radial force arising from radial tire deflection, the side force arising due to slip angle and inclination angle, and the circumferential force arising from applied torque. Since the roadway is treated as a flat, horizontal plane, a "point-contact" representation of the tire is used to obtain the radial loading. The circumferential force calculation uses a two-straight-line approximation of friction coefficient-slip behavior. The side force calculations are based on slip-angle and inclination-angle properties of the tires which are saturated at large angles. Interaction between circumferential and side forces utilizes a modified "friction-ellipse" concept which "rolls off" side force as a function of tire slip. The "rolloff" characteristic is an empirical relationship obtained from tire test data. The tire aligning torque and overturning moment are modeled as nonlinear functions of lateral force, normal force, and inclination angle. To account for differences in tire characteristics at the front and rear wheels, provisions are made to input separate parameter sets for front and rear tires.

Open-loop control inputs can be entered in the form of steering wheel angle and drive or brake torque. The drive torque is generated to maintain a constant velocity of the vehicle. The brake torque magnitude is determined from input data functions of brake line pressure at the front and rear wheels. Since the equations of motion are written in

terms of a moving vehicle axis system, a coordinate transformation is required to relate the vehicle's position and orientation with respect to an orthogonal coordinate system fixed in space.

2.2.2 Allocation of Analog and Digital Computer Tasks

Since the model is solved on a hybrid computer, it must be subdivided for solution into equations to be solved on the analog computer and those to be solved on the digital computer. The allocation of computing tasks was determined using the following guidelines:

(1) Function generation requiring extensive algebraic calculations or reference to tables of values should be performed in the digital computer.

(2) System variables determined from the solution of differential equations should be graded according to response time (time constant). The differential equations representing the fastest variables should be solved on the analog computer, and the remaining on the digital computer.

Slight compromises to the task allocation determined from the above rules were required due to limitations in digital computer computation speed, numbers of analog computer computation modules, and available analog-to-digital and digital-to-analog data communications modules.

The present allocation of computing tasks between the analog and digital computers is presented in Figure 2-1. Calculated in the digital portion are the sprung mass equations of motion, wheel orientation angles, and tire force equations. Wheel brake and drive torques, velocities of the tire contact point, and resultant forces and moments are also computed in the digital portion.

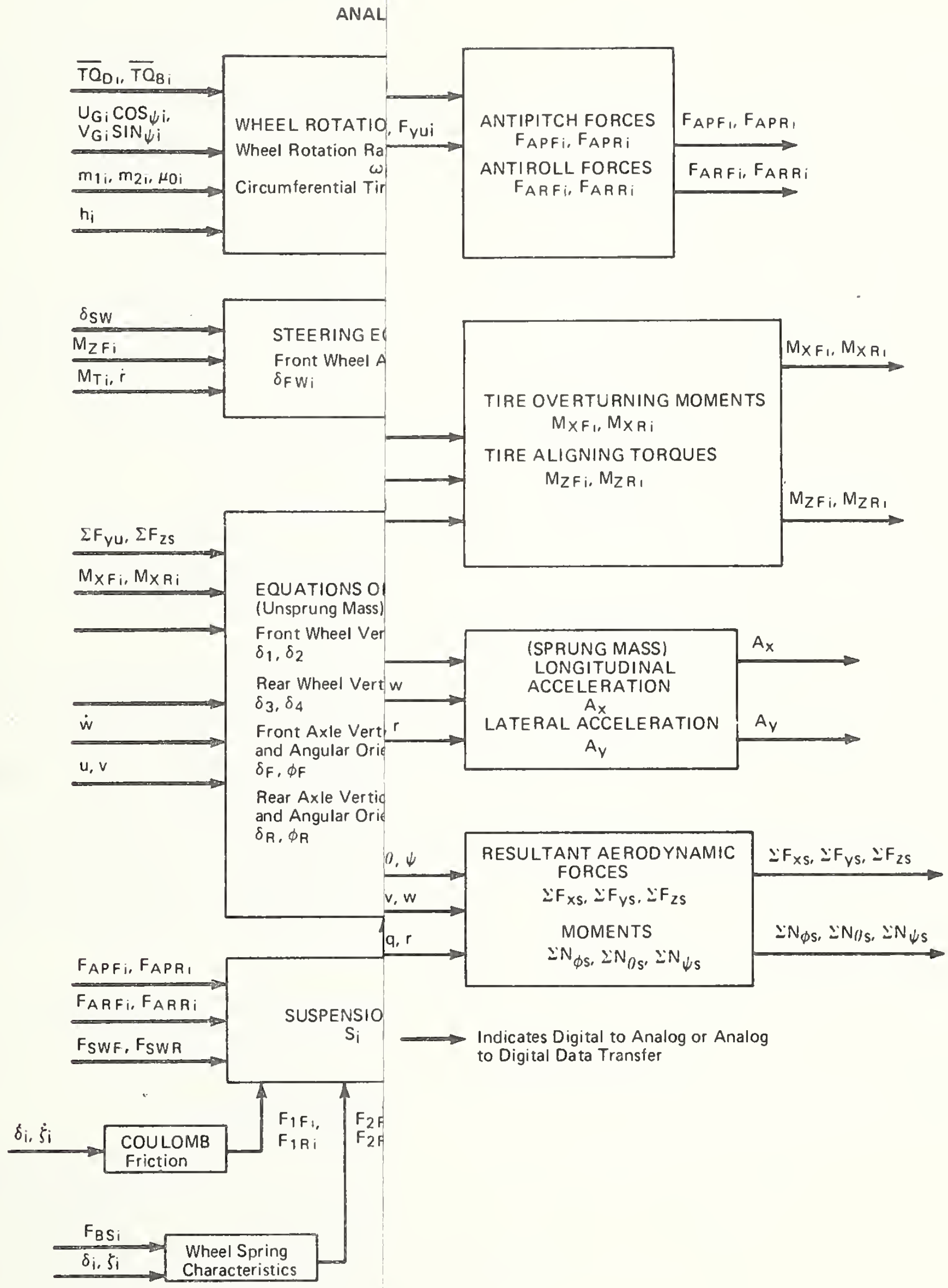
The analog computations include the suspension forces, shock absorber and wheel spring functions, longitudinal wheel slip, and circumferential coefficient of friction. In addition, the equations of motion of the unsprung masses and steering system equations are solved on the analog computer.

The hybrid simulation is time scaled to run at one-fourth real time, i.e., twenty seconds of clock-on-the-wall time is required for five seconds of vehicle simulation.

2.2.3 Implementation of the Mathematical Model

2.2.3.1 Analog Portion

The APL/JHU hybrid computer facility (Appendix C) contains analog machines manufactured by Electronic Associates, Inc. (EAI). The portion of model programmed on the analog computer is divided between models of EAI analog computers. The entire steering system is contained on an EAI 231-R and the rotational wheel dynamics, circumferential friction coefficient calculation, tire deflection, and suspension dynamics contained on an EAI 680. Data communication with the digital computer is provided by 24 multiplying



imulation Block Diagram of the HVHP Model

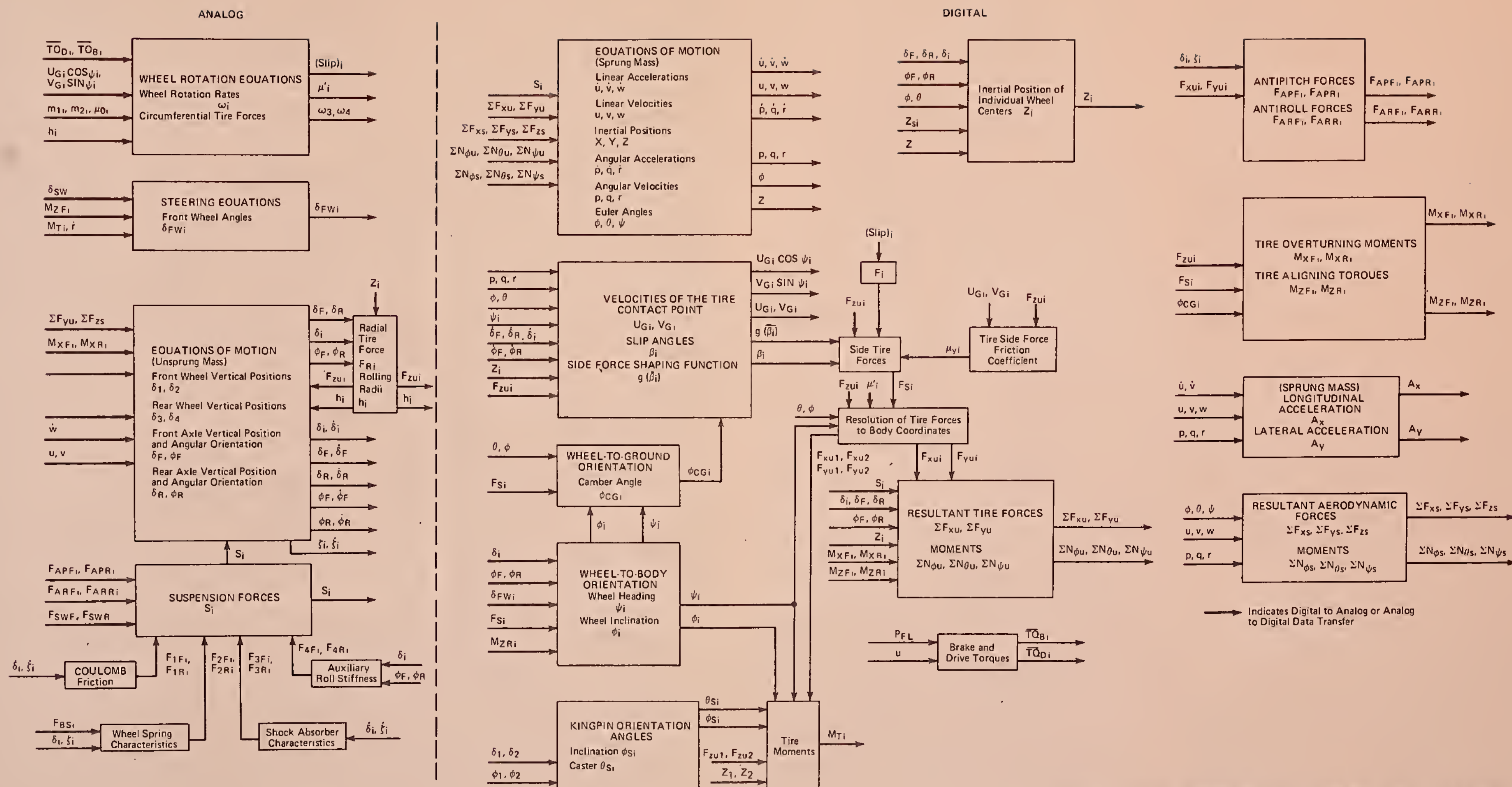


Fig. 2-1 Hybrid Simulation Block Diagram of the HVHP Model

2.3 USER'S INTERFACE

The interface between the engineering user and the computer has been designed to maximize user control and information retrieval from the hybrid computer [13]. The interface has been implemented by a set of generalized input/output subroutines. Using these communication routines, the following necessary tasks can be accomplished interactively at the CRT hybrid control console:

- Interrogation of any digital variable, including arrays, by name.
- Assignment of new values to any digital parameter or initial condition.
- Tracking and printing the values of any digital variable as a function of time.
- Printing the end of run values of any digital variable or parameter.
- Performing automatically a group of parametric runs varying one or more parameters or initial conditions by an arbitrary amount.
- Assigning new digital variables to the DAC's (digital-to-analog converters) and ADC's (analog-to-digital converters).

- Rescaling the digital variables output on the DAC's or input on the ADC's.

- Commenting the computer output with observations pertinent to the computer runs.

- Printing the value of all digital variables on command.

The usefulness of these routines is augmented by having the following features:

- The output unit for all digital computer responses is selectable (line printer, CRT, or both).

- Extensive subroutine error recovery which allows operation by untrained personnel.

- Free format input which obviates the need to always insert decimal points, spaces, etc. which would be required by Fortran syntax.

An explanation of the modules which are the building blocks of the routines, as well as a discussion of interaction, is presented in Appendix D.

2.4 VHTP MANEUVERS AND PERFORMANCE COMPARISON VARIABLES

Due to the importance of handling test procedures in vehicle research, the HVHP was programmed to automatically

perform those defined for passenger cars [10]. The associated performance comparison variables (PCV's) for the VHTP's are also calculated. Since test procedures generally employ the input commands of braking, steering, and combinations of braking and steering, the HVHP implementation can generally be used to generate test procedures for all types of vehicles. The performance comparison variables are less general and refer specifically to the NHTSA passenger vehicle VHTP's defined in Reference [10].

2.4.1 VHTP Maneuvers

The simulation has the capability of self-initializing to perform any of the six automobile VHTP maneuvers and calculating the performance comparison variables appropriate for the selected VHTP. Utilizing the communication routines, a VHTP is selected by addressing the Fortran variable VHTPNO and assigning it a value from 1 to 6. The value of 0 is reserved for a special check run that verifies correct dynamic operation of the simulation. Once a VHTP has been selected, the system forcing function, pertinent to the VHTP, can be accessed. For all VHTP's the Fortran variable PFL represents brake line pressure. For VHTP's 2 to 6, the steering wheel input has the Fortran name STR2, STR3, etc. The names PFL, STR2, etc. can be used in the multi-run routine to simulate a series of VHTP tests in which the brake line pressure or steering wheel input is incremented. By convention, when a VHTP is selected in which the steering input is normally a parameter (VHTP 2, 4, 5), the STR variable contains

the steering wheel rotation required to input 2.0 degrees of normalized steer. This value is required for run series in which the steering is incremented.

2.4.2 VHTP Performance Comparison Variables

Performance comparison variables are output in both the single run and multiple run modes. If a single run is executed, a general comparison variable format is selected in which all PCV's are output. However, only those pertinent to the selected VHTP will be non-zero. If a series of runs is executed, the output is in a tabular format with the forcing function (steering wheel angle or brake line pressure) starting in the left column followed by the pertinent PCV's. An example is presented in Figure 2-2, in which the following occurs:

(1) VHTP 4 is selected

(2) The STR4 variable is interrogated to determine the steering wheel rotation for 2 degrees of normalized steer.

(3) The steering wheel input is set equal to 300 degrees.

(4) A single run is executed.

(5) A run series of four runs is set up with STR4 initialized to two degrees normalize steer (NS) and incremented by two degrees NS in each run.

(6) A multiple run is executed.

(7) The program is terminated.

A representative parametric run series for each VHTP is presented in Figures 2-3a to 2-3f. Performance Comparison Variable graphs for four vehicles are presented in Appendix F.

2.5 VALIDATION

The HVHP has been used extensively for predicting vehicle performance while APL has worked cooperatively with many NHTSA contractors. Through cooperative research efforts with four different NHTSA contractors the HVHP has been validated at least once for each type of suspension configuration and many times for the standard American passenger car suspension. In each case validation consisted of the contractor comparing simulation and full scale test time history responses. Therefore, in addition to APL validation, the HVHP performance has been examined by engineers with extensive backgrounds in vehicle handling.

2.5.1 NHTSA Research Programs

The following are summaries of recently completed NHTSA research programs in which the HVHP was utilized.

2.5.1.1 Passenger Car Tire Effects Program

The HVHP was used extensively for vehicle simulation while APL worked cooperatively with the Calspan Corp.

on DOT contract HS-053-3-727 [7]. For this contract, "Research on the Influence of Tire Properties on Vehicle Handling," Calspan was responsible for refining the tire/road interface model which APL incorporated into the HVHP. Calspan monitored the simulation modification and examined the output for authenticity.

In the performance of this research over 2000 simulated VHTP's were run. Four vehicles were simulated: Chevrolet Brookwood station wagon, Dodge Coronet, Pontiac Trans Am, and Volkswagen Super Beetle. For each vehicle, a complete set of VHTP's was performed using simulated OE (original equipment) tires. Parametric studies were then performed, varying tire parameters to determine their effect on vehicle handling performance. The performance comparison variable graphs for the original equipment tire configuration runs are presented in Appendix F of this report.

2.5.1.2 VHTP's for Recreational Vehicles

The HVHP was used extensively for vehicle simulation while APL worked cooperatively with the Dynamic Science Division of Ultrasystems, Inc. on DOT contract HS-4-00853 [14]. For this research, " Handling Test Procedures for Light Trucks, Vans and Recreational Vehicles", Dynamic Science was responsible for redefining the HVHP model to simulate a wider class of vehicles. During the course of this contract the suspension options were broadened to permit simulation of any of the following suspension types:

```
TERMINAL ACTIVE
        HYBRID VEHICLE HANDLING PROGRAM
 HYBRID COMPUTER PROB*  91
CARNEW    LOAD MODULE
DODGE71 VEHICLE

 ENGAGE PATCH PANEL FOR TEST
 TYPE CR WHEN READY
****
MAY        12  1976
TIME  11:15: 0.46
OPTION
****  F
ENTER
****  VHTPNO 4
****
OPTION
****  IC
OPTION
****  F
ENTER
****  STR4
   27.93
****  STR4 300
****
OPTION
****  X
MAY        12  1976
TIME  11:16: 0.94
RUN   1 HAS STARTED
OUTPUT BELOW
 AXAV=   0.0   DECL TIME=   0.000 AVCUR=   0.720 BTDMAX=   0.222 BTMAX=   0.171 DELBT=   0.172
AYMAX=   0.762 PHIMAX=   7.754 RMAX=   0.572 LANE CHNG DEL=   0.0   DELPSI=   0.0   MAX STEER= 300.000
FTRQMAX=        0. RTRQMAX=        0.

OPTION
****  F
ENTER
****  VHTPNO 4
****
OPTION
****  MULTI
NUM OF LOOPS,VARS
****  4 1
VAR
****  STR4
LOOP,VAL,INC
****  1 27.9 27.9
****
OPTION
****  XM
MAY        12  1976
TIME  11:17:24.42
RUN   2 HAS STARTED
OUTPUT BELOW
MULTI TOTAL STR4..(   1) BETAMX(   1) BETDMX(   1) CUVRAT(   1) AYMAX.(   1) RMAX..(   1)
  1     2       27.9       0.363E-02    0.123E-01    0.579E-01    0.754E-01    0.431E-01
  2     3       55.8       0.104E-01    0.331E-01    0.150        0.187        0.114
  3     4       83.7       0.196E-01    0.538E-01    0.247        0.305        0.184
  4     5       112.       0.340L )1    0.761E-01    0.344        0.422        0.256
OPTION
****  TERM
MAY        12  1976
TIME  11:19:11.53
PROGRAM TERMINATED
```

Fig. 2-2   HVHP User's Interactive Control

```
OPTION
****  F
ENTER
****  VHTPNO 1
****
OPTION
****  IC
OPTION
****  MULTI
NUM OF LOOPS,VARS
****  4 1
VAR
****  PFL
LOOP,VAL,INC
****  1 300 100
****
OPTION
****  XM
MAY       10  1976
TIME  10:54:25.90
RUN   7 HAS STARTED
OUTPUT BELOW
MULTI TOTAL PFL...(   1) AXAVE.(   1) TIMDEC(   1) AYMAX.(   1) SLIPI.(   1) SLIPI.(   2) SLIPI.(   3) SLIPI.(   4)
  1     7       300.        -0.417          2.74      0.128E-01    0.890E-01    0.889E-01    0.873E-01    0.869E-01
  2     8       400.        -0.556          2.05      0.110E-01    0.117        0.117        0.119        0.117
  3     9       500.        -0.650          1.76      0.335E-01    0.140        0.148        1.00         1.00
  4    10       600.        -0.654          1.74      0.226E-01    1.00         0.998        1.00         1.00
```

Fig. 2-3a HVHP Interaction for VHTP No. 1

```
OPTION
****  F
ENTER
****  VHTPNO 2
****
OPTION
****  IC
OPTION
****  MULTI
NUM OF LOOPS,VARS
****  4 1
VAR
****  PFL
LOOP,VAL,INC
****  1 300 100
****
OPTION
****  XM
MAY        10  1976
TIME  15: 9:20.16
RUN   3 HAS STARTED
OUTPUT BELOW
MULTI TOTAL PFL...(   1) AXAVE.(   1) AYMAX.(   1) BETDMX(   1) CUVRAT(   1) SLIPI.(   1) SLIPI.(   2) SLIPI.(   3) SLIPI.(   4)
  1     3       300.       -0.422       0.300      0.252E-01     1.10      0.915E-01    0.825E-01    0.901E-01    0.813E-01
  2     4       400.       -0.533       0.300      0.479E-01     1.16      0.121        0.107        1.00         0.117
  3     5       500.       -0.655       0.300      0.580E-01     0.369     1.00         0.131        1.00         0.156
  4     6       600.       -0.666       0.300      0.738E-01     0.209     1.00         0.999        1.00         1.00
```

Fig. 2-3b HVHP Interaction for VHTP No. 2

```
OPTION
****  F
ENTER
****  VHTPNO 3
****
OPTION
****  IC
OPTION
****  F
ENTER
****  STR3 139
****
OPTION
****  MULTI
NUM OF LOOPS,VARS
****  3 2
VAR
****  BMPN
LOOP,VAL,INC
****  1 8 0
****  2 10 0
****  3 13 0
****
VAR
****  BMPS
LOOP,VAL,INC
****  1 57.6 0
****  2 48.0 0
****  3 37.7 0
****
OPTION
****  XM
MAY        10  1976
TIME  15:43:28.49
RUN   2 HAS STARTED
OUTPUT BELOW
MULTI TOTAL BMPN..(   1) BMPS..(   1) AYMAX.(   1) RMAX..(   1) CUVRAT(   1) BETDMX(   1)
  1     2       8.00         57.6        0.584        0.331        0.858        0.129
  2     3      10.0          48.0        0.786        0.389        0.876        0.373
  3     4      13.0          37.7        0.787        0.336        0.793        0.224
```

Fig. 2-3c HVHP Interaction for VHTP No. 3

```
 OPTION
****  F
ENTER
****  VHTPNO 4
****
OPTION
****  IC
OPTION
****  F
ENTER
****  STR4
   27.93
****
OPTION
****  MULTI
NUM OF LOOPS,VARS
****  4 1
VAR
****  STR4
LOOP,VAL,INC
****  1 55.86 55.86
****
OPTION
****  XM
'MAY        10  1976
TIME  11:11: 1.18
RUN  18 HAS STARTED
OUTPUT BELOW
MULTI TOTAL STR4..(    1) BETAMX(    1) BETDMX(    1) CUVRAT(    1) AYMAX.(    1) RMAX..(    1)
  1     18        55.9        0.105E-01    0.336E-01     0.150         0.189         0.115
  2     19        112.        0.346E-01    0.775E-01     0.346         0.425         0.257
  3     20        168.        0.709E-01    0.125         0.493         0.589         0.386
  4     21        223.        0.112        0.177         0.606         0.687         0.474
```

Fig. 2-3d HVHP Interaction for VHTP No. 4

```
OPTION
****  F
ENTER
****  VHTPNO 5
****
OPTION
****  IC
OPTION
****  F
ENTER
****  STR5
   27.93
****
OPTION
****  MULTI
NUM OF LOOPS,VARS
****  4 1
VAR
****  STR5
LOOP,VAL,INC
****  1 55.86 55.86
****
OPTION
****  XM
MAY        10  1976
TIME  11:17:20.88
RUN  22 HAS STARTED
OUTPUT BELOW
MULTI TOTAL STR5..(   1) AYMAX.(   1) DEL...(   1) BETAMX(   1) DELPSI(   1) UIN...(   1)
  1     22        55.9          0.181          9.73       0.141E-01    0.903E-02     45.0
  2     23        112.          0.386          6.40       0.411E-01   -0.135E-02     45.0
  3     24        168.          0.525          4.54       0.829E-01   -0.142E-01     45.0
  4     25        223.          0.640          5.88       0.136       -0.464E-01     45.0
```

Fig. 2-3e HVHP Interaction for VHTP No. 5

```
OPTION
****  F
ENTER
****  VHTPNO 6
****
OPTION
****  IC
OPTION
****  F
ENTER
****  BRKON
  0.5200
****
OPTION
****  MULTI
NUM OF LOOPS,VARS
****  3 1
VAR
****  BRKOFF
LOOP,VAL,INC
****  1 0.9 0.05
****
OPTION
****  XM
MAY        10  1976
TIME  16:40:10.20
RUN   2 HAS STARTED
OUTPUT BELOW
MULTI TOTAL PHIMAX(   1) PHIDMX(   1) RMAX..(   1) ZIMX..(    1) ZIMX..(   2) ZIMX..(   3) ZIMX..(   4) UIN...(   1) BRKOFF(   1)
  1     2        7.95        0.748        0.455      -0.208E-02     0.676        0.157        0.330        50.0         0.900
  2     3        8.04        0.721        0.455      -0.208E-02     0.671        0.151        0.331        50.0         0.950
  3     4        8.02        0.682        0.455      -0.220E-02     0.660        0.151        0.334        50.0         1.00
```

Fig. 2-3f HVHP Interaction for VHTP No. 6

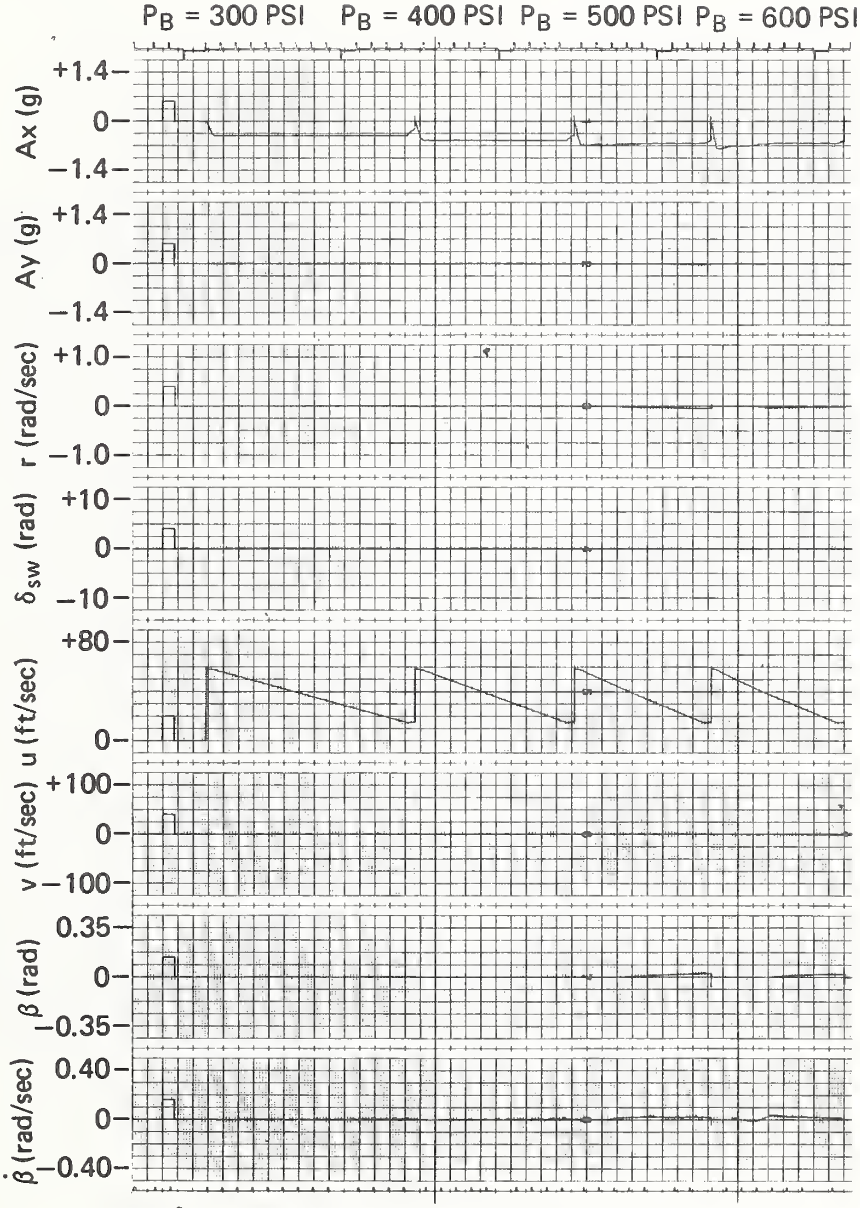


Fig. 2-4a Time Histories — Straight Line Braking

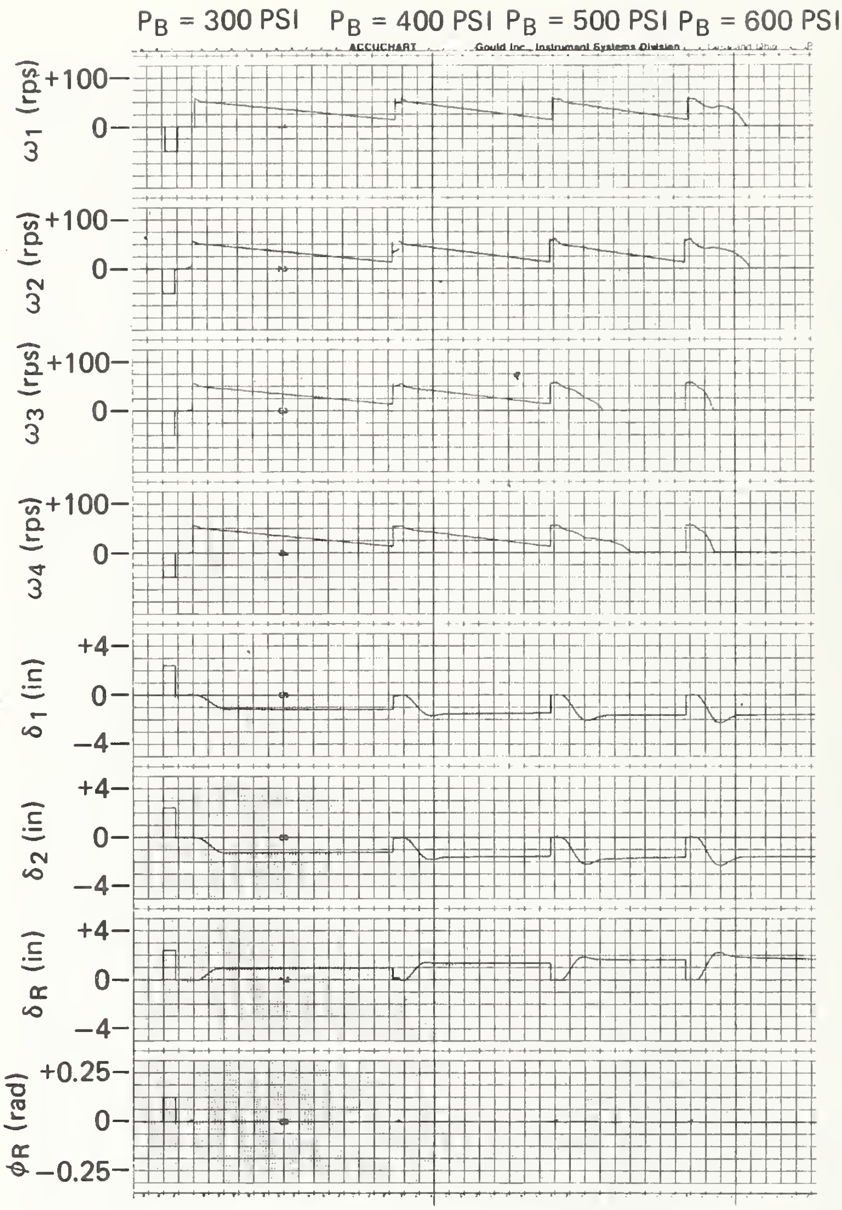


Fig. 2-4b Time Histories — Straight Line Braking

Fig. 2-5a Time Histories — Braking in a Turn

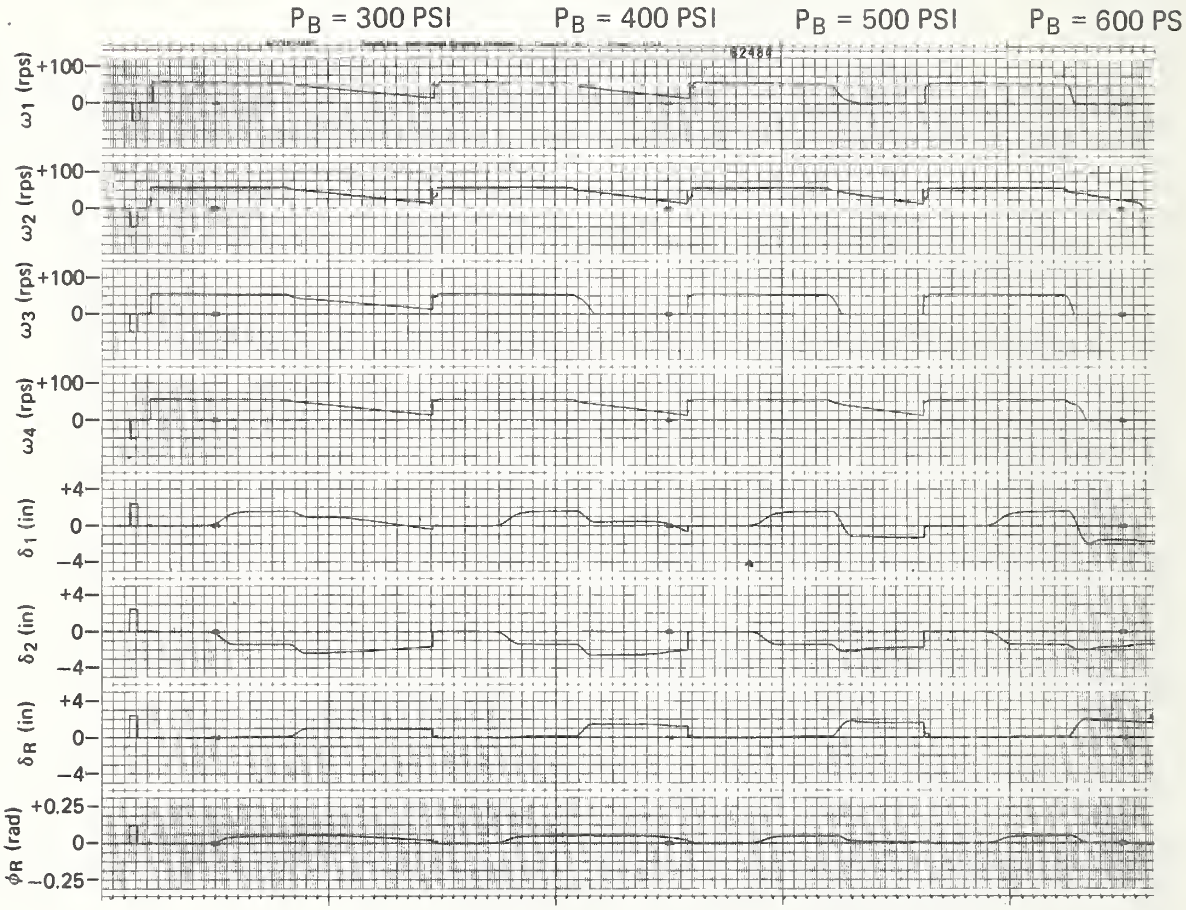


Fig. 2-5b Time Histories — Braking in a Turn

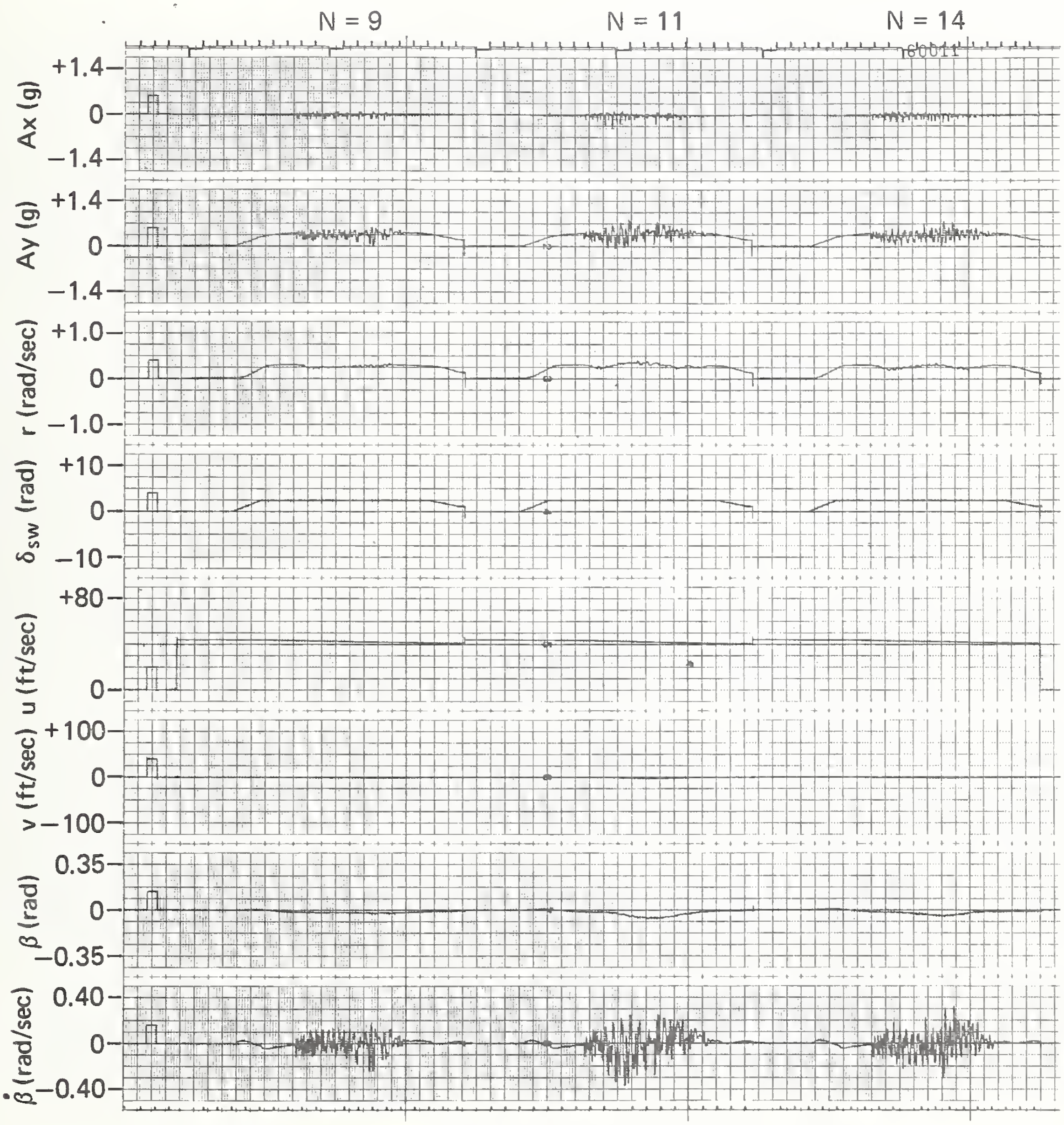


Fig. 2-6a Time Histories — Turning on a Rough Road

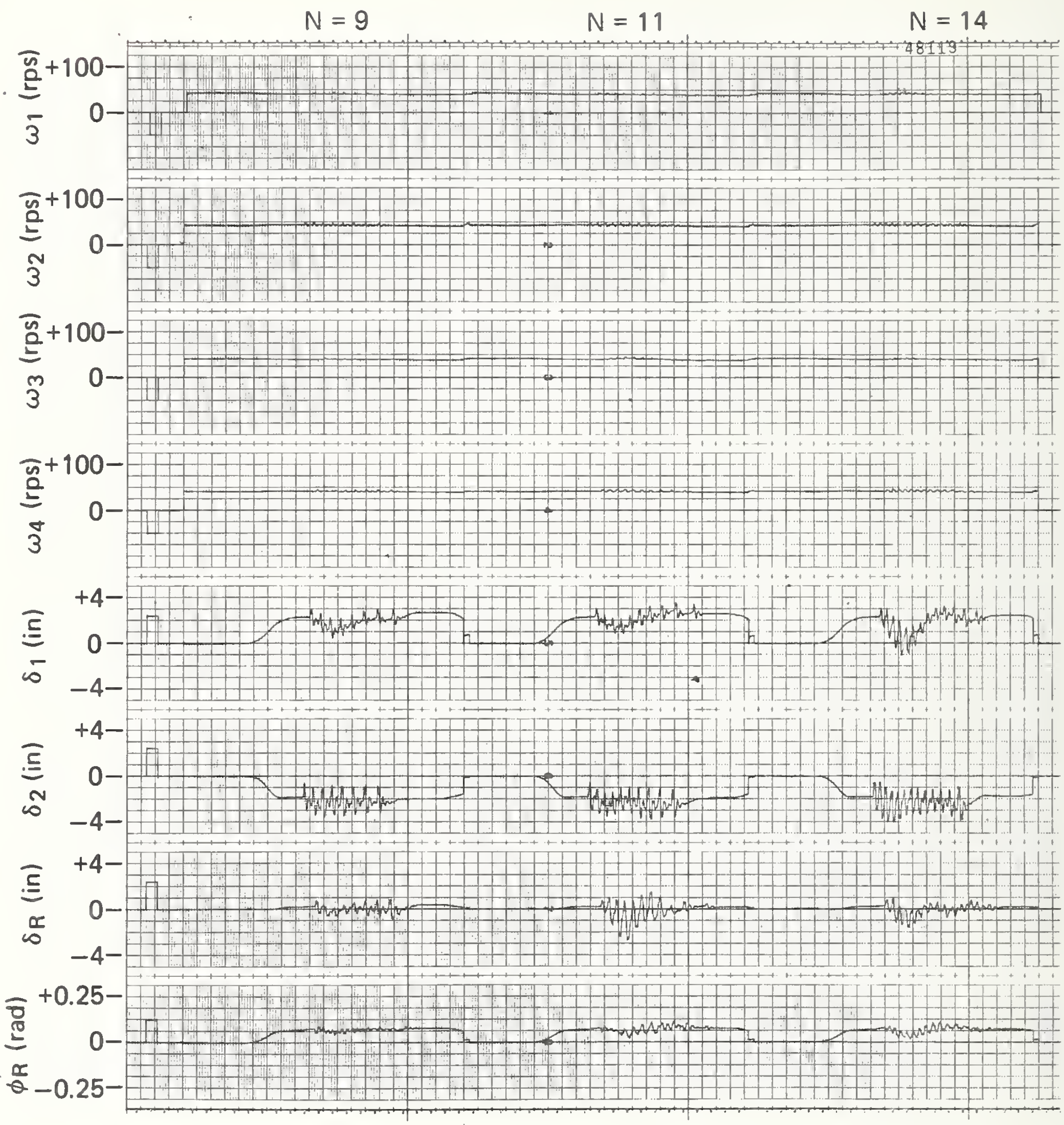


Fig. 2-6b Time Histories — Turning on a Rough Road

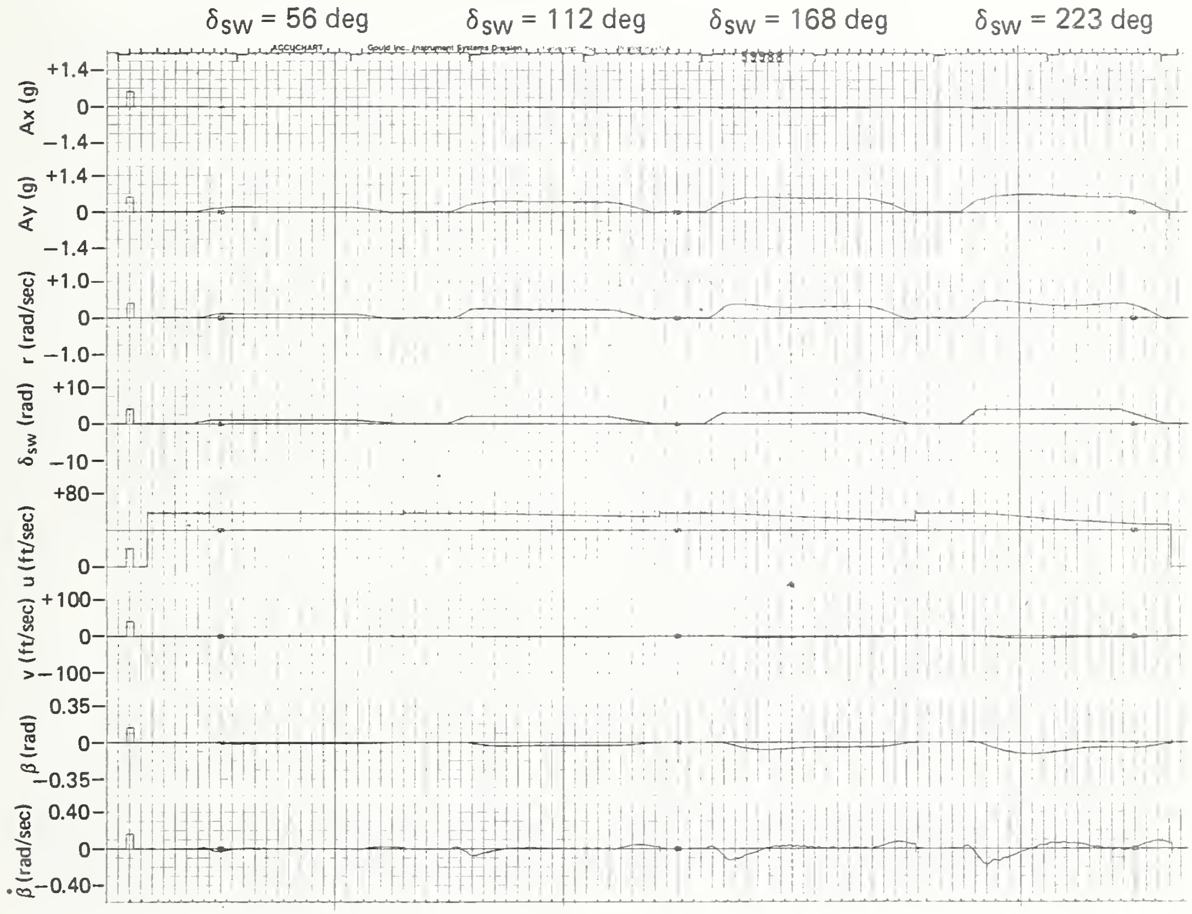


Fig. 2-7a Time Histories — Trapezoidal Steer

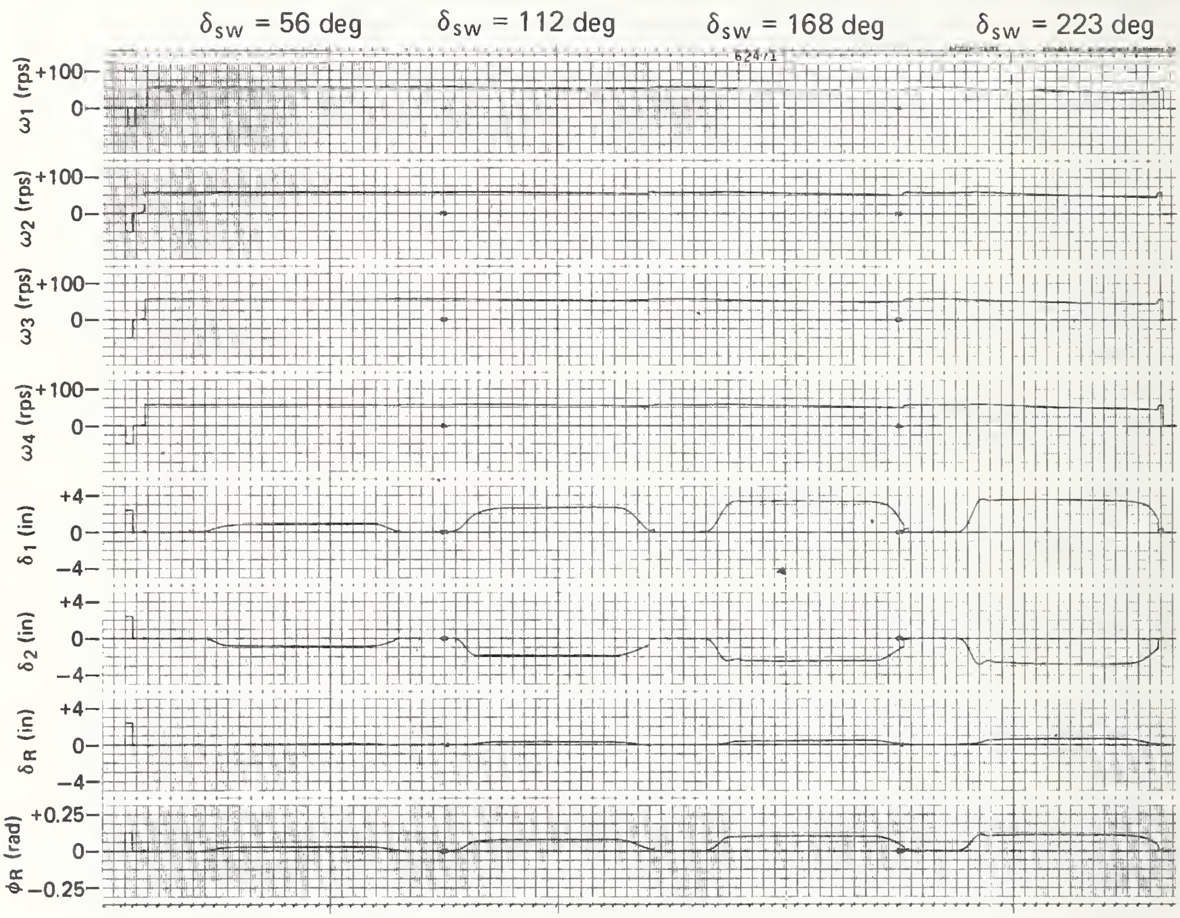


Fig. 2-7b Time Histories — Trapezoidal Steer

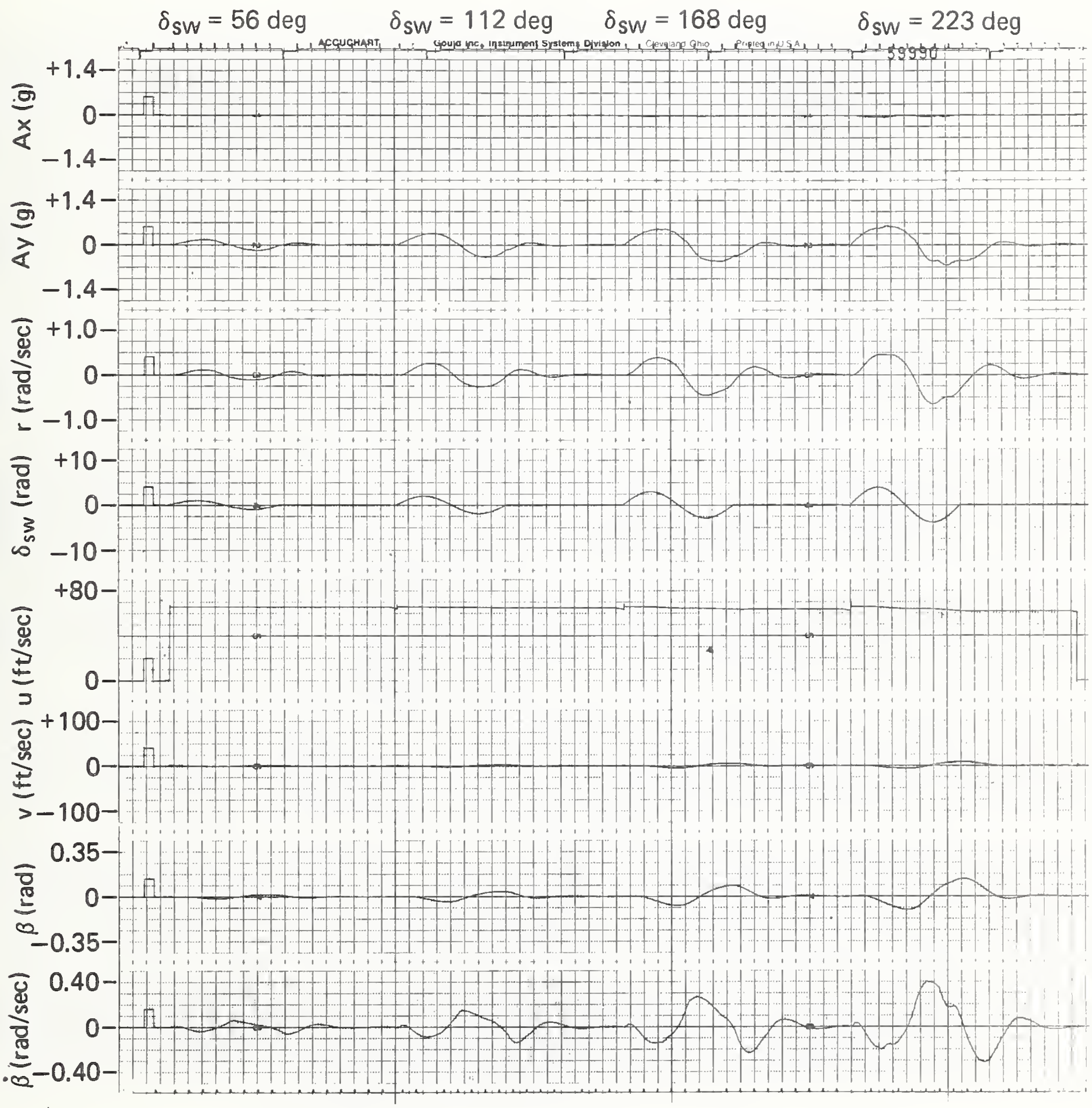


Fig. 2-8a Time Histories - Sinusoidal Steer

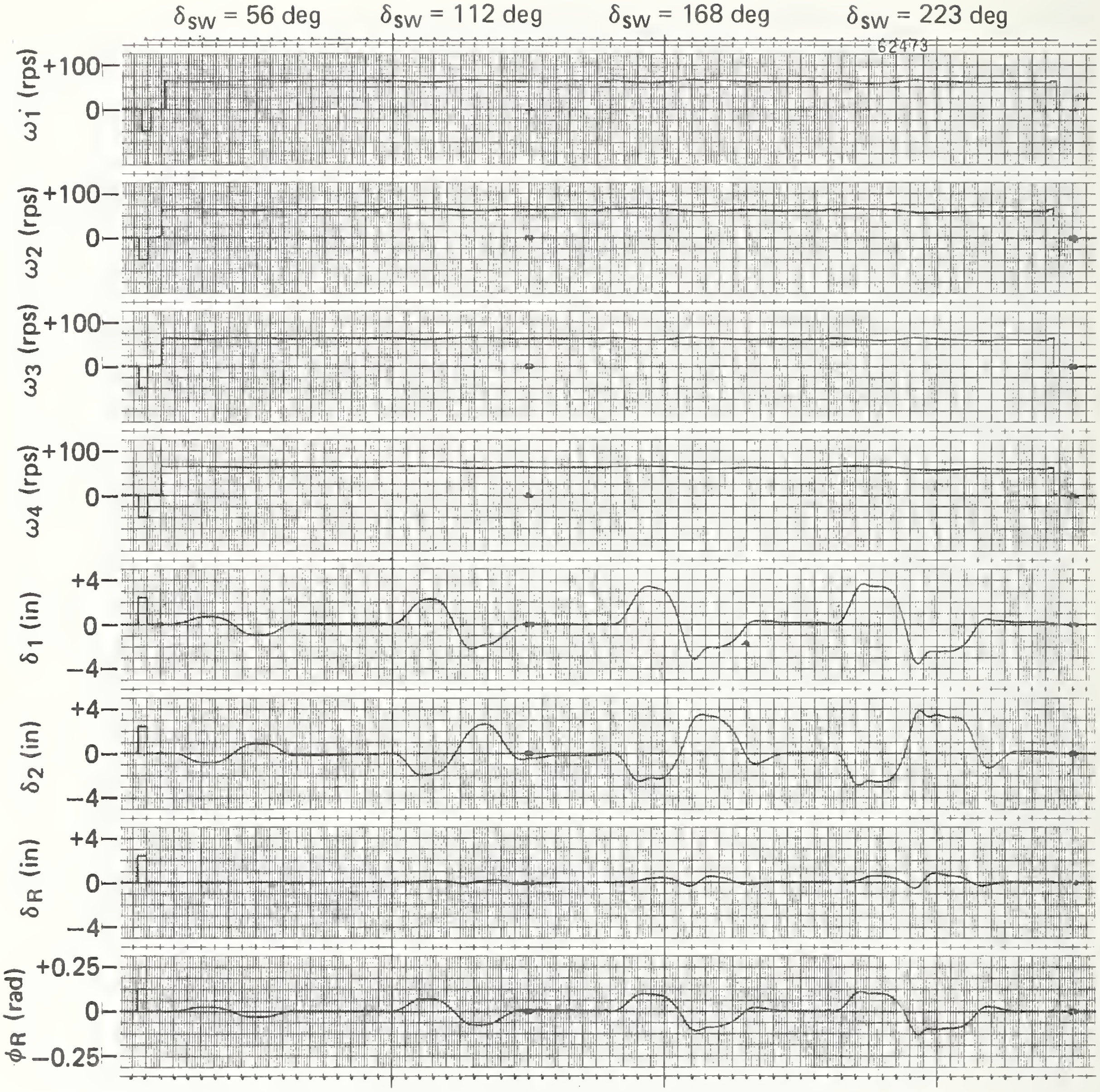


Fig. 2-8b Time Histories — Sinusoidal Steer

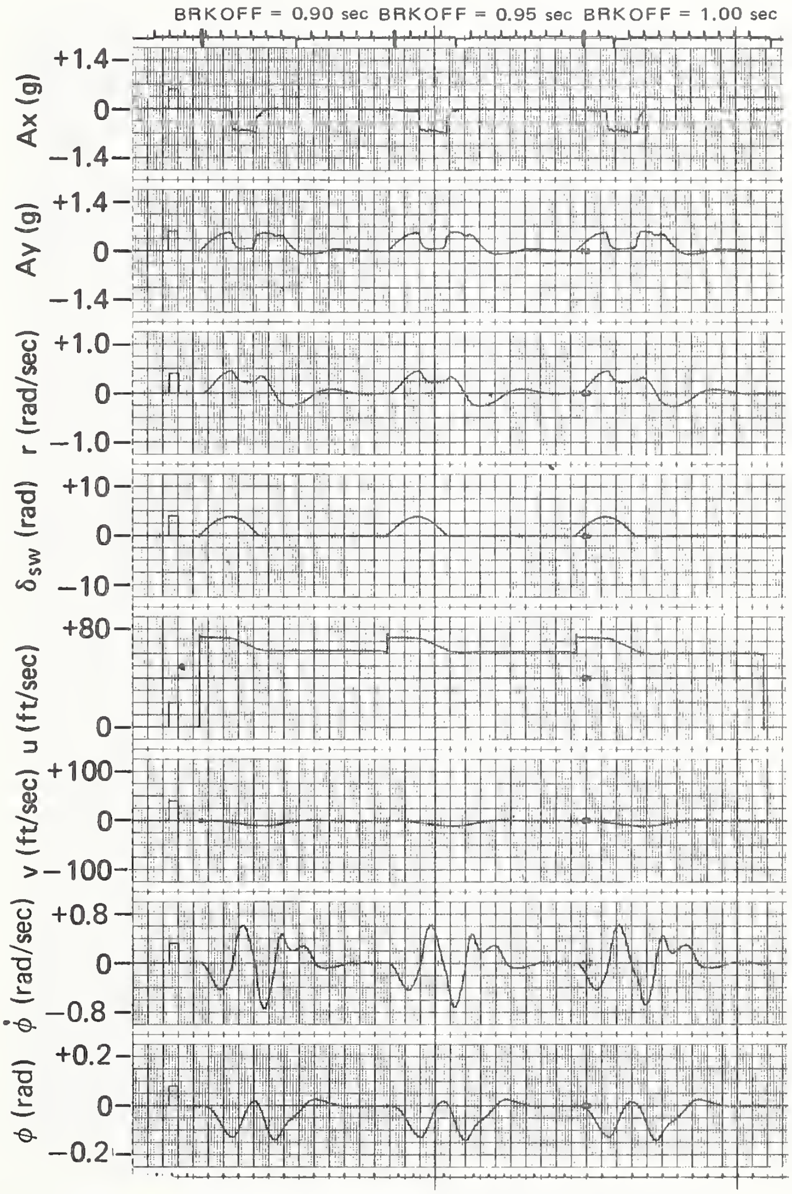


Fig. 2-9a Time Histories — Drastic Steer and Brake

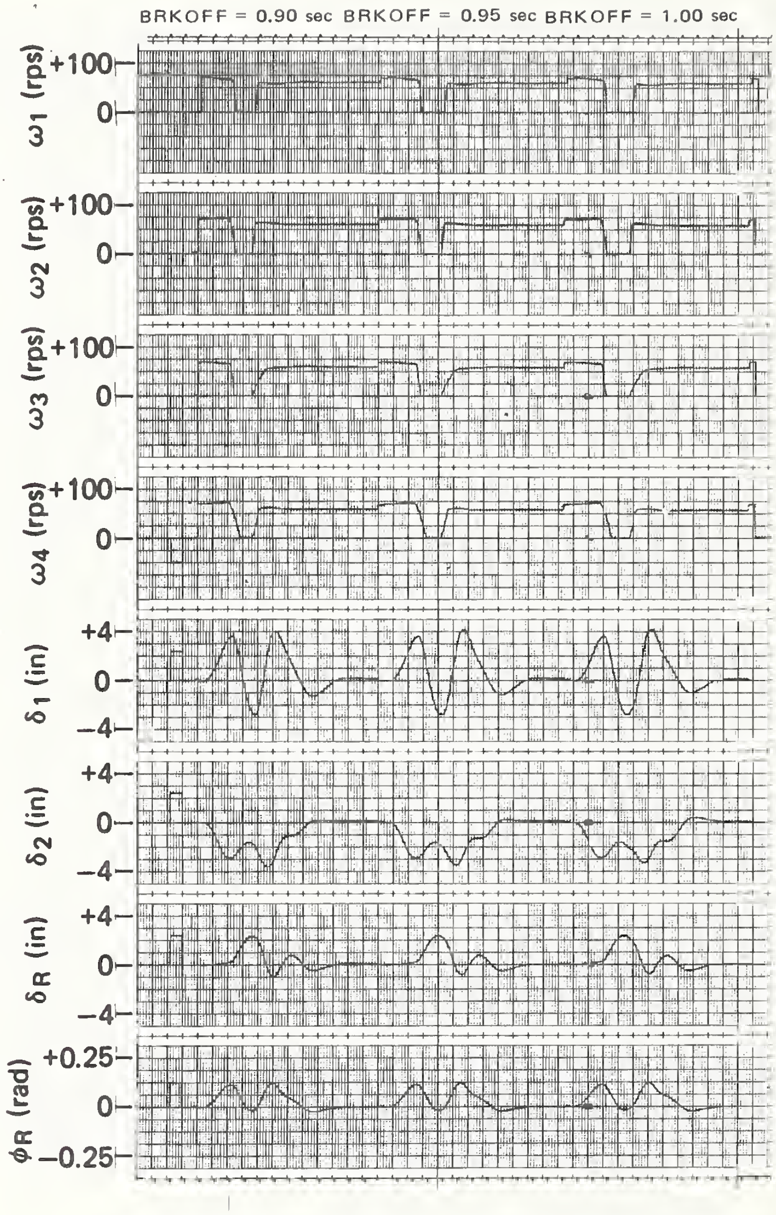


Fig. 2-9b Time Histories — Drastic Steer and Brake

(1) independent front and rear

(2) independent front and solid rear axle

(3) solid front and solid rear axle

(4) Dual tires on a solid rear axle with either independent front wheels or a solid front axle

A model representing vehicle aerodynamic properties was also added at this time.

In the performance of this research, over 2500 recreational vehicle VHTP's were run and five vehicles were simulated: Ford F-250 pickup truck equipped with a representative 11 foot camper, Volkswagen Campmobile, Jeep Wagoneer, Open Road motor home (type C), and a Winnebago motor home (type A). Parametric studies were performed on these vehicles to determine appropriate handling test procedures for small trucks and recreational vehicles. This research effort is documented in References [6] and [14].

2.5.1.3 Truck and Bus Tire Effects Program

The HVHP was used extensively for vehicle simulation while APL worked cooperatively with HSRI (Highway Safety Research Institute, University of Michigan) on DOT contract HS-4-00943 [15]. For this research, "Effects of Tire Properties on Truck and Bus Handling", HSRI provided APL with tire model refinements that simplified the simulation of truck tire

forces and moments. Trapezoidal and sinusoidal steer VHTP's were performed using simulated OE (original equipment) tires. Parametric studies were then performed using the same VHTP's varying tire parameters to determine their effect on vehicle handling performance.

In the performance of this research, over 1500 simulated VHTP's were run and four vehicles were simulated: Ford Econoline Van, Ford F-250 pickup truck, White tractor, and a GMC intercity bus.

2.5.1.4 Passenger Cars Pulling Trailers

The HVHP was used for vehicle simulation while APL worked cooperatively with STI (Systems Technology, Inc.) on DOT contract HS-4-00900 [16]. For this research, "Passenger Cars and Light Trucks Pulling Trailers", STI was responsible for defining a trailer model that was compatible with the HVHP and could be added to it. During the course of this research a model of a one or two axle trailer connected to a tow vehicle via a ball hitch was incorporated into the HVHP. Braking, steering, and combined braking and steering simulation runs were performed. The simulated tow vehicle was a Chevrolet Caprice station wagon and the towed vehicle was a single axle trailer.

2.5.2 Vehicle Handling Test Procedures

Time Histories for a typical set of VHTP manevers is presented in Figures 2-4 to 2-9. The vehicle simulated for these runs is the 1971 Dodge Coronet. A general discussion of HVHP simulation output is presented in Appendix G.

2.5.2.1 Straight Line Braking

This run series determines the value of brake line pressure at which two wheels on the same axle lock-up. For this vehicle, both rear wheels were locked at 500 psi and all four wheels were locked at 600 psi.

2.5.2.2 Braking In a Turn

This run series determines the value of brake line pressure at which two wheels on the same axle lock-up while the vehicle is executing a constant 0.3 gee turn. For this vehicle, the inside rear wheel was locked at 400 psi, both inside wheels were locked at 500 psi, and all four wheels were locked at 600 psi.

2.5.2.3 Turning On a Rough Road

For this run series, the vehicle traverses a bump grid while in a steady 0.4 gee turn. Three grid frequencies are simulated: 9, 11, and 14 Hz.

2.5.2.4 Trapezoidal Steer

In this run series, trapezoidal steers of 4, 8, 12 and 16 degrees of normalized steer angle were used. For this vehicle, 28 degrees of steering wheel angle is required for 2 degrees of normalized steer.

2.5.2.5 Sinusoidal Steer

In this run series, sinusoidal steers with a maximum amplitude of 4, 8, 12 and 16 degrees of normalized steer angle were used. For this vehicle, 28 degrees of steering wheel angle is required for 2 degrees of normalized steer.

2.5.2.6 Drastic Steer and Brake

The purpose of these runs is to determine vehicle roll-over tendency. For this vehicle, a peak roll angle of 0.14 radians and a peak roll rate of 0.75 radians per second was achieved.

2.6 TIRE DATA

As previously stated, the current HVHP tire/road interface model was defined by Calspan as part of DOT contract HS-053-3-727 [7]. For this contract, Calspan tested many tires at their TIRF (Tire Research Facility) testing complex [11]. As a convenience for working with APL and using the HVHP, the TIRF associated computer was programmed to process tire data into a format directly compatible with the HVHP tire model. Therefore, very little effort is required to prepare tire data for input to the HVHP for tires which have been tested on the TIRF machine. For tires tested on other tire test machines or flat bed testers, APL can convert the data for HVHP use with the TIRF computer data processing program. When the tire test data has been properly formatted, the

program output will be compatible with the HVHP. However, data preparation for the latter approach can be very time consuming. A recent tire parameter determination research program has made available HVHP compatible data on approximately 400 tires of sizes usually found on passenger cars and light trucks. These tire data along with documentation of the research can be found in Reference [17].

2.6.1 Tire Data Validation

A tire/road interface plotting program [18] was developed at APL to validate tire model data used as input to the vehicle simulation. The validation approach was to generate families of curves of desired tire/road interface functions for chosen sets of conditions which could be correlated with data obtained from tire tests. Given values for the coefficients and parameters of the tire model equations, the program calculates the tire model functions and produces data deck compatible with the input requirements of a Calcomp plotting subprogram [19]. Tire/road interface graphs are then generated by the subprogram. Representative graphs are shown in Appendix H.

2.7 HVHP INPUT DATA

2.7.1 Data Deck Description

A general input data deck is used with the HVHP. Defined in the data deck are the following:

(1) Program identification

(2) Default output variable list for the Track Option.

(3) Default output variable list for the Table Option for VHTP's performed in the multi-run mode.

(4) Digital-to-analog converter variable and scale factor assignments input as pairs of digital variable and corresponding scale factor.

(5) Analog-to-digital converter variable and scale factor assignments input as pairs of digital variables and corresponding scale factor.

(6) Initialization of non-integer parameters or initial conditions.

(7) Initialization of integer parameters or initial conditions.

(8) Vehicle simulated.

(9) Front and rear camber, caster, and toe functions via coefficients for a fifth order polynomial approximation.

(10) Front and rear brake torques as pairs of brake pressure in, brake torque out data points.

(11) Lateral friction coefficient degradation with circumferential slip as pairs of percent slip in, percent of lateral friction coefficient out data points.

(12) Aerodynamic force and moment coefficients as pairs of aerodynamic angle of attack in, aerodynamic coefficient out data points.

(13) Front and rear spring data as pairs of suspension deflection in, spring force out.

(14) Wind profile data as pairs of distance in, wind velocity out.

(15) PARAM data array members which are used to redefine VHTP condition inputs as sequential numbers representing the PARAM array element number and the corresponding variable value for the initial check run and each VHTP number 1 to 6.

(16) Initial values of individual members of the PARAM vehicle descriptor data array input as pairs of array element number and initial value.

The input data for three recently simulated vehicles which are representative of the HVHP suspension types are presented in Appendix E. Also presented in Appendix E is a sample of the PARAM Table for each vehicle which is output to the system line printer prior to each simulation run. This provides PARAM value documentation. The three vehicles for which data are provided are:

(1) VW Campmobile, independent front and rear suspension

(2) Dodge Coronet independent front solid rear axle suspension

(3) Winnebago Motor Home, solid front and rear axle suspension with dual rear tires.

2.7.1.1 Program Identification

The first data card identifies the APL problem number, the digital computer load module, and the vehicle simulated.

2.7.1.2 Track Output Variables

The next group of cards defines the initial set of interactive variables to be output when the track OPTION is enabled. Fifty variables may be selected on as many cards as is required. This group of cards is terminated by a blank card. This list may be altered interactively using the Track OPTION.

2.7.1.3 Table Output Variables

The next group of cards defines the variables to be output at the end of each run when the multiple run execution mode is enabled. This group contains seven cards, one card for each VHTP (the first six) and one for the check run. A maximum of nine variables can be specified per card. If the Table variables are respecified interactively via the Table OPTION for the execution of a VHTP, the variables in this data group will be restored when that VHTP is reselected.

2.7.1.4 Digital-to-Analog Variables

This group of cards specifies which variables will be output from the digital to the analog computer and the scale factor that will be associated with the digital-to-analog conversion (DAC). Any variable may be output. If the variable output is used in the closed loop vehicle model, the scale factor must be consistent with the use of the variable on the analog computer. If the variable output is used strictly for strip chart recorder display purposes, the scale factor can take on any rational value. The maximum expected value of the variable is an appropriate starting value. Either the variable, scale factor, or both may be reassigned via the interactive OPTION DACA. Forty-eight cards must be included, one for each digital-to-analog output in the order of assignment to the DAC's 0-47. Each card contains a variable name followed by its normalizing scale factor. The list is terminated by the character string ENDNODAC.

2.7.1.5 Analog-to-Digital Variables

This group of cards specifies which variables will be input from the analog to the digital computer and the scale factor that will be associated with the analog-to-digital conversion (ADC). Any variable name which has been specified as an interactive variable and exists on the analog computer may be input. The scale factor must be consistent with the use of the variable on the analog computer. Either the variable, scale factor, or both may be reassigned via the interactive OPTION ADCA. A change in variable implies a wiring change on the analog patch panel. Twenty-eight cards must be included, one for each analog-to-digital input in the order of assignment to ADC's 0-27. Each card contains a variable name followed by its analog scale factor. Only 28 of the available 48 ADC channels are used by the HVHP. The list is terminated by the character string ENDNOADC.

2.7.1.6 Non-Integer Variable Initialization

The next group of cards allows any non-integer initial condition or parameter that has been specified as an interactive variable to be assigned an initial value. The format is a name followed by the initial value with a maximum of ten pairs per card. Any number of cards is allowed and the input is terminated by a blank card.

2.7.1.7 Integer Variable Initialization

The next group of cards allows any integer parameter that has been specified as an interactive variable to be assigned an initial value. The format is a name followed by the initial value with a maximum of ten pairs per card. Any number of cards is allowed and the input is terminated by a blank card.

2.7.1.8 Vehicle Identification

This data card is used to document the vehicle being simulated. Any message confined to 80 characters is allowed.

2.7.1.9 Camber, Caster, and Toe Functions

The next six data cards define the front wheel camber, caster, and toe and the rear wheel camber, caster, and toe functions in degrees for wheel displacement (inches) from the unloaded vehicle suspension equilibrium position. One function is defined per data card which contains the six coefficients required to specify a fifth order polynomial approximation to the appropriate function. The order of the data is C0, C1, ..., C5. C0 is the value of the function (camber, caster, toe) at the equilibrium suspension position of the unloaded vehicle. The vehicle simulation uses the right front and rear wheels as a reference for camber and toe data. The sign of the coefficients for the left front and rear wheels is changed in the digital program. Data for these functions for the representative vehicles are presented in Appendix E.

2.7.1.10 Brake Torques

The next group of data cards defines the front and rear brake torque functions. The function is specified as pairs of data points one pair per card, a value of brake line pressure (pounds) and the corresponding value of the brake torque (inch-pounds). A group of cards (2 to 19) defining each function is ended by a data card containing the number 99999. A linear interpolation routine is used to obtain torque values for brake line pressures between specified data values. Conventionally, the front and rear brake torque functions are identical and brake proportioning is accomplished using PARAM array elements 238-241.

2.7.1.11 Side Force Shaping Function

The next group of data cards defines the functional relationship between the side force and circumferential slip. Pairs of data points are input one pair per card as percent of slip and the corresponding percent of possible side force which is attained. The function data (2 to 19 cards) is terminated by a card containing the number 99999. Linear interpolation is used between data points to obtain intermediate function values.

2.7.1.12 Aerodynamic Coefficients

The next groups of data cards define the aerodynamic force and moment coefficients as tabular functions of the aerodynamic side slip angle or angle of attack. Each

function is input as pairs of data points one pair per card with a maximum of 19 cards. The format is an angle of attack (radians) followed by the value of the aerodynamic coefficient. The input order of the functions is axial force (C_x), side force (C_y), normal force (C_z), roll moment (C_l), pitch moment (C_m) and yaw moment (C_n). Each functions data cards are terminated by the number 99999. A linear interpolation routine is used to obtain function values for angles of attack between specified data values.

2.7.1.13 Spring Functions

The next groups of cards define the front and rear spring functions as tabular functions of suspension deflection from the equilibrium position. Each function is input as pairs of data points, one pair per card, with a maximum of nine cards. The format is a suspension deflection (inches) followed by the spring force (pounds). The data is input for the range from full compression to full rebound. The input order of the spring forces is right front, left front, right rear, left rear. Each function's data cards are terminated by the number 99999. A linear interpolation routine is used to obtain function values for deflections between specified data values.

The spring force at each wheel is implemented as the sum of a linear segment generated on the analog computer and a digital supplement which is the difference between

the analog value and the actual spring characteristic. The sign convention for deflections from equilibrium, which is zero inches and a corresponding suspension force of zero pounds, is as follows:

(1) compression is a negative deflection and produces a negative suspension force.

(2) rebound is a positive deflection and produces a positive suspension force.

Spring data for three representative vehicles is presented in Appendix E.

2.7.1.14 Wind Profile

The next group of data cards defines the aerodynamic wind disturbance profile. Pairs of data points are input as tabular functions of longitudinal distance to the center of the wind disturbance profile and cross wind velocity. The function is input as pairs of data points, one point per card, with a maximum of 19 cards. The format is a distance (inches) followed by the wind velocity (inches/second). The data points are terminated by a card containing 99999. A linear interpolation routine is used to obtain cross wind velocity for longitudinal distance between specified data points.

2.7.1.15 VHTP Initialization Data

The next group of cards allows the input of data that is used for initialization of the simulation for

performing a specific VHTP maneuver. Since this data is input, VHTP conditions can easily be varied. Twenty-seven data cards are required with each card containing a PARAM element address and a value for the variable represented by that address for the check verification run and each VHTP 1 to 6, in that order. The PARAM element addresses shown in the data lists are required for VHTP initialization. However, the input order is not fixed.

2.7.1.16 Vehicle Descriptor and Tire Data

The last group of cards is used to input the initial values of variables which are elements of the PARAM data array. This array is used to input all vehicle descriptor and tire model data. Since the array is also used for purposes other than data input, such as storing values for program calculated initial conditions, program flow switch values, etc., all PARAM elements need not be initialized. The definitions of all PARAM elements is presented in Section 4 of Appendix B. The subset of PARAM elements which represent vehicle descriptors or tire model coefficients is presented in Section 5 of Appendix B. Data is input one PARAM element per card by indicating the PARAM element address followed by the assigned value.

2.7.2 Shock Absorbers and Load Dependent Data

In addition to the data deck, the shock absorber functions are simulation inputs. The shock absorber functions are input using analog function generators.

2.7.2.1 Shock Absorber Functions

The front and rear shock absorber functions are generated using analog function generators. Since the function generator is a versatile analog device, the shock absorber characteristic can be represented as a general function of suspension deflection rate. However, in practice, representation by three or four line segments has proven sufficient. The function may be specified for input purposes either graphically or as a list of slopes for various suspension deflection rates. The sign convention for suspension motion from equilibrium, which is zero rate (inches per second) and a corresponding zero damping force (pounds), is as follows:

(1) A negative suspension deflection rate (compression motion) produces a negative shock absorber force.

(2) A positive suspension deflection rate (rebound motion) produces a positive shock absorber force.

Shock absorber data for three representative vehicles are presented in Appendix E.

2.7.2.2 Load Dependent Data

Since the HVHP calculates suspension deflections relative to the suspension equilibrium position for all load

configurations, information specifying the suspension travel from the unloaded vehicle suspension position must be provided. Of particular interest are the loaded vehicle configurations for driver control used in VHTP's 1-3 and for automatic controller used in VHTP's 4-6. The vehicle parameters which are load dependent and their corresponding PARAM element addresses are as follows:

Variable	PARAM Address
MS	1
ZF	4
ZR	5
a	6
b	7
IX	11
IY	12
IZ	13
DELF	92
DELR	93

SECTION 3
CONCLUSIONS AND RECOMMENDATIONS

The Hybrid Computer Vehicle Handling Program (HVHP) has demonstrated realistic dynamic simulations of passenger vehicles and trucks with suspensions ranging from four wheel independent to solid front and rear axles. The performance of simulation runs, especially those involving the six vehicle handling test procedures (VHTP), are inexpensively and easily performed. In addition, the performance measuring Vehicle Performance Comparison Variables (PCV) for each VHTP are also provided.

Although good correlation between the HVHP and full-scale test data has been achieved, it is recommended that changes in all areas of the model, including the tire/road interface, the vehicle description, etc., be given serious consideration where an improvement in correlation could result. The HVHP has proved to be a good simulation which is easily extended to meet the increasing needs of predicting vehicle behavior. By critically reviewing the simulation with each use and making improvements the HVHP will continue to be a successful engineering tool.

APPENDIX A

VEHICLE MATHEMATICAL MODEL

1. INTRODUCTION

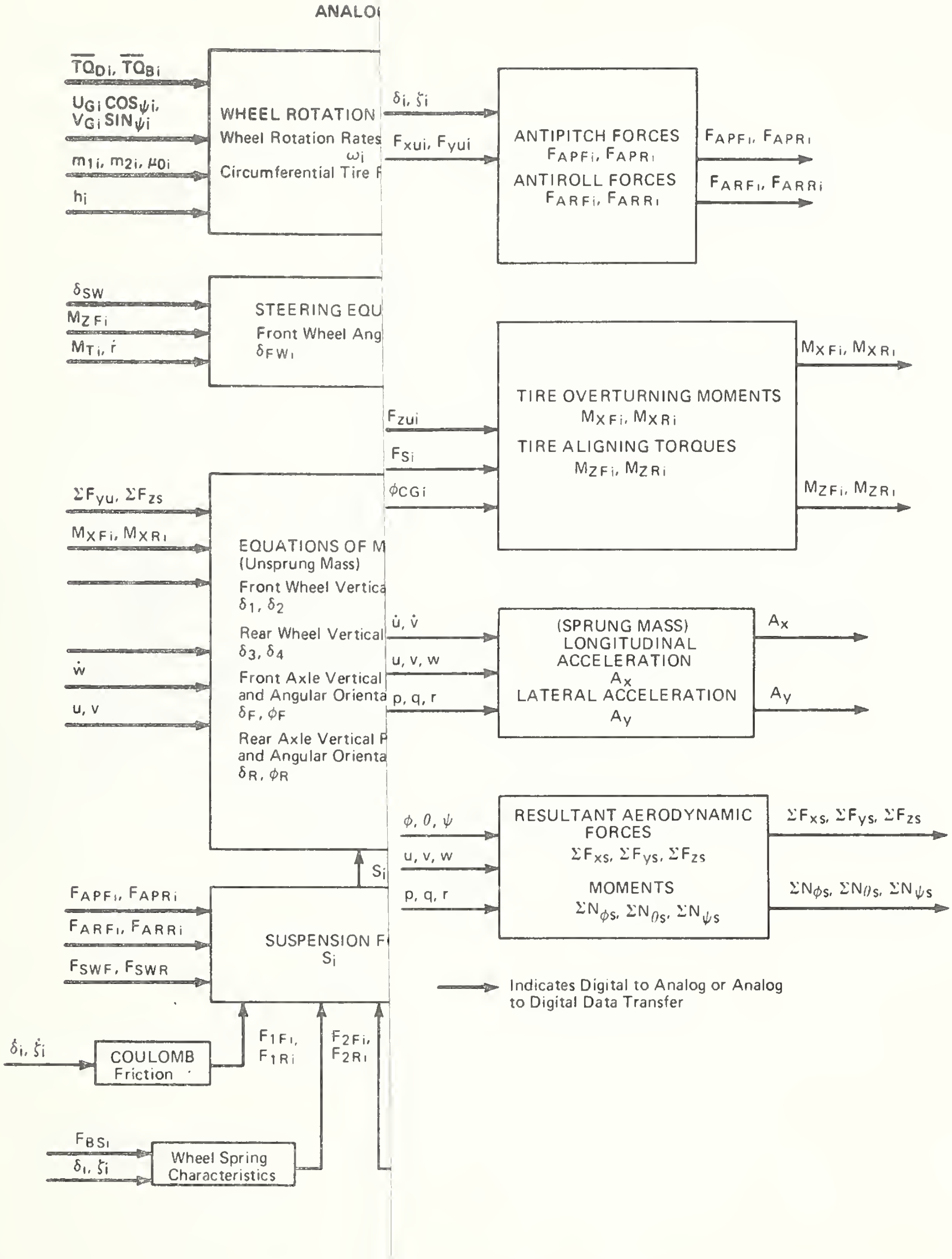
This Appendix contains the vehicle mathematical model which was implemented on the APL/JHU hybrid computer. The equation numbers associated with a particular suspension, axial or tire configuration will include a notation from the following legend:

- A solid front axle
- B solid rear axle
- C independent front suspension
- D independent rear suspension
- E solid front and rear axles
- F independent front suspension and solid rear axle
- G independent front and rear suspensions
- H independent front suspension and dual tires on solid rear axle
- I solid front axle and dual tires on solid rear axle

2. SYSTEM EQUATIONS

2.1 Table of Contents

2.1 Table of Contents (continued)



id Simulation Block Diagram of the HVHP Model

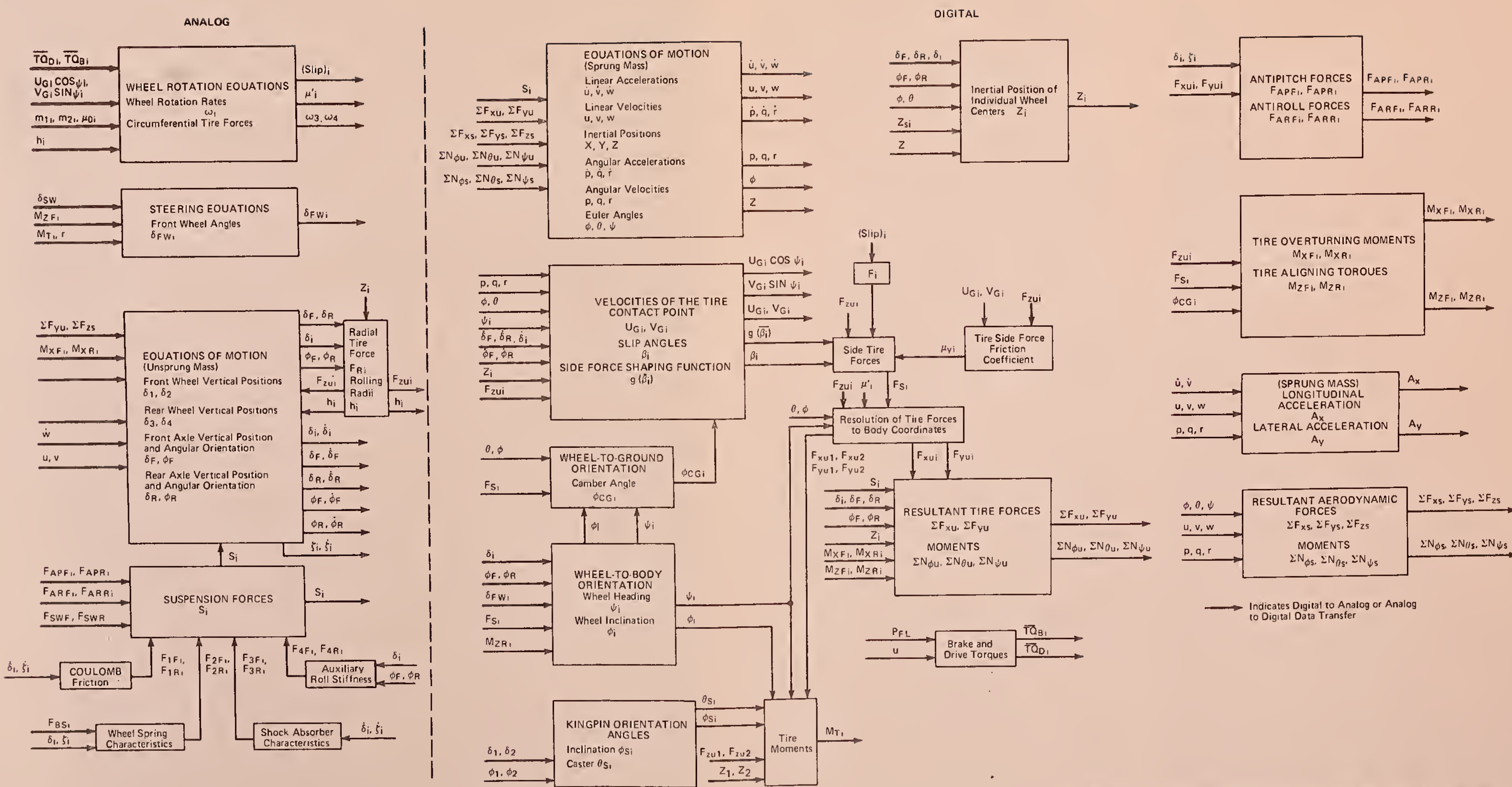


Fig. A-1 Hybrid Simulation Block Diagram of the HVHP Model

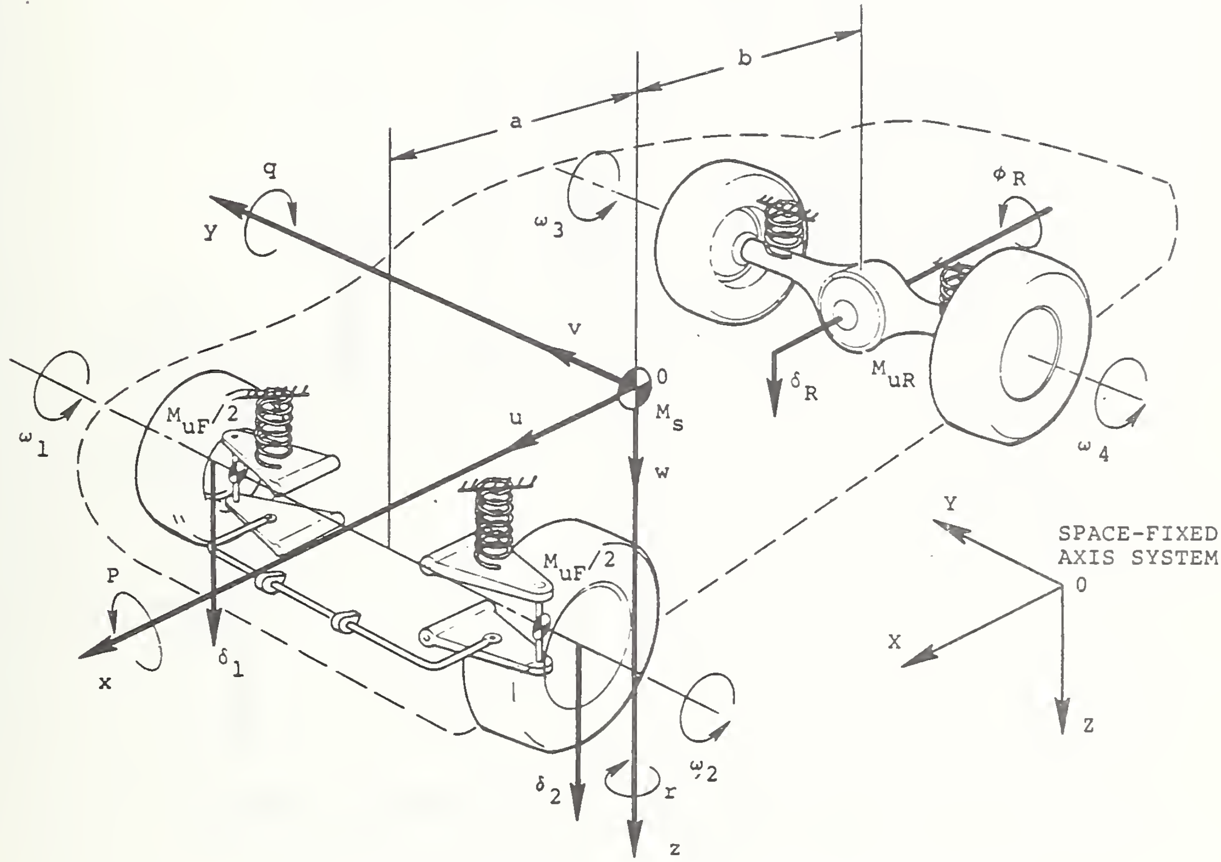


Fig. A-2 Analytical Representation of the Vehicle Model

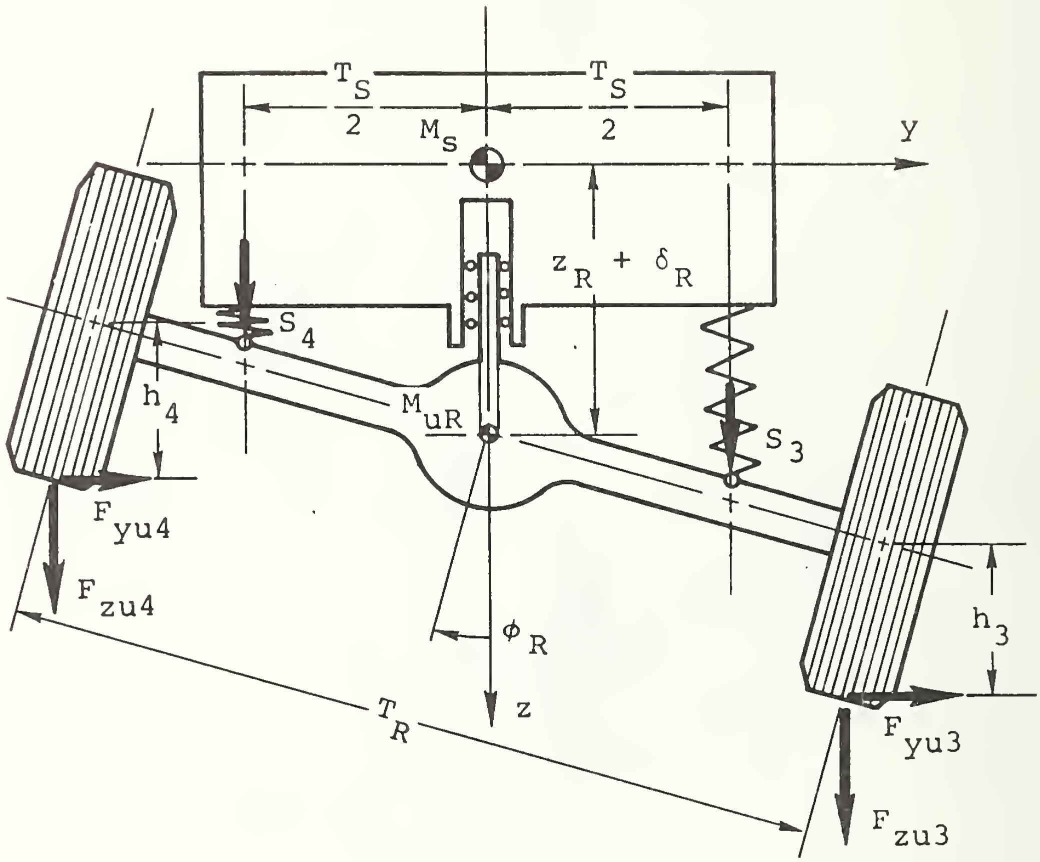


Fig. A-3 Analytical Representation of the Solid Rear Axle Model

2.2 Equations of Motion (Ten Degrees of Freedom)

The equations of motion of the sprung and unsprung masses are presented below:

$$(\Sigma\ M)\ \dot{u} + \gamma_2\ \dot{q} = (\Sigma\ M)\ (vr - wq - g\ \theta) + \Sigma\ F_{xu} + \Sigma\ F_{xs} \tag{1}$$

$$(\Sigma\ M)\ \dot{v} - \gamma_2\ \dot{p} + \gamma_1\ \dot{r} = (\Sigma\ M)\ (wp - ur + g\ \phi) + \Sigma\ F_{yu} + \Sigma\ F_{ys} \tag{2}$$

$$M_s\ \dot{w} = M_s\ (uq - vp + g) - \sum_{i=1}^{4} S_i + \Sigma\ F_{zs} \tag{3}$$

$$-\gamma_3\ \dot{v} + (I_x + I_x')\ \dot{p} - (I_{xz} + I_{xz}')\ \dot{r} = \gamma_3\ (ur - wp - g\ \phi) + \Sigma\ N_{\phi u} + \Sigma\ N_{\phi s} \tag{4}$$

$$\gamma_2\ \dot{u} + (I_y + I_y')\ \dot{q} = \gamma_2\ (vr - wq - g\ \theta) + \Sigma\ N_{\theta u} + \Sigma\ N_{\theta s} \tag{5}$$

$$\gamma_1\ \dot{v} - (I_{xz} + I_{xz}')\ \dot{p} + (I_z + I_z' + I_F + I_R)\ \dot{r} = \gamma_1\ (wp - ur + g\ \phi) + \Sigma\ N_{\psi u} + \Sigma\ N_{\psi s} \tag{6-E}$$

$$\gamma_1\ \dot{v} - (I_{xz} + I_{xz}')\ \dot{p} + (I_z + I_Z' + I_R)\ \dot{r} = \gamma_1\ (wp - ur + g\ \phi) + \Sigma\ N_{\psi u} + \Sigma\ N_{\psi s} \tag{6-F}$$

$$\gamma_1\ \dot{v} - (I_{xz} + I_{xz}')\ \dot{p} + (I_z + I_z')\ \dot{r} = \gamma_1\ (wp - ur + g\ \phi) + \Sigma\ N_{\psi u} + \Sigma\ N_{\psi s} \tag{6-G}$$

$$M_{uF}\,\dot{w} - M_{uF}\,a\,\dot{q} + M_{uF}\,\ddot{\delta}_F = M_{uF}\,(uq - vp + g)$$

$$+ F_{zu1} + F_{zu2} + S_1 + S_2 \tag{7-A}$$

$$M_{uR}\,\dot{w} + M_{uR}\,b\dot{q} + M_{uR}\,\ddot{\delta}_R = M_{uR}\,(uq - vp + g)$$

$$+ F_{zu3} + F_{zu4} + S_3 + S_4 \tag{8-B}$$

$$I_F\,\dot{p} + I_F\,\ddot{\phi}_F = \Sigma\,N_{\phi F} \tag{9-A}$$

$$I_R\,\dot{p} + I_R\,\ddot{\phi}_R = \Sigma\,N_{\phi R} \tag{10-B}$$

$$\frac{M_{uF}}{2}\,\dot{w} + \frac{M_{uF}\,T_F}{4}\,\dot{p} - \frac{M_{uF}\,a}{2}\,\dot{q} + \frac{M_{uF}}{2}\,\ddot{\delta}_1$$

$$= \frac{M_{uF}}{2}\,(uq - vp + g) + F_{zu1} + S_1 - F_{yu1}\,\mathrm{TAN}\left(\frac{2H_{FC}}{T_F}\right) \tag{11-C}$$

$$\frac{M_{uF}}{2}\,\dot{w} - \frac{M_{uF}\,T_F}{4}\,\dot{p} - \frac{M_{uF}\,a}{2}\,\dot{q} + \frac{M_{uF}}{2}\,\ddot{\delta}_2$$

$$= \frac{M_{uF}}{2}\,(uq - vp + g) + F_{zu2} + S_2 + F_{yu2}\,\mathrm{TAN}\left(\frac{2H_{FC}}{T_F}\right) \tag{12-C}$$

$$\frac{M_{uR}}{2}\dot{w} + \frac{M_{uR}\,b}{2}\dot{q} + \frac{M_{uR}\,T_R}{4}\dot{p} + \frac{M_{uR}}{2}\ddot{\delta}_3$$

$$= \frac{M_{uR}}{2}(uq - vp + g) + F_{zu3} + S_3 - F_{yu3}\,\mathrm{TAN}\left(\frac{2H_{RC}}{T_R}\right) \quad (13\text{-}D)$$

$$\frac{M_{uR}}{2}\dot{w} + \frac{M_{uR}\,b}{2}\dot{q} - \frac{M_{uR}\,T_R}{4}\dot{p} + \frac{M_{uR}}{2}\ddot{\delta}_4$$

$$= \frac{M_{uR}}{2}(uq - vp + g) + F_{zu4} + S_4 + F_{yu4}\,\mathrm{TAN}\left(\frac{2H_{RC}}{T_R}\right) \quad (14\text{-}D)$$

where

$$\Sigma M = M_s + M_{uF} + M_{uR} \quad (15)$$

$$I'_x = M_{uF}\,z_F^2 + M_{uR}\,z_R^2 \quad (16)$$

$$I'_y = I'_x \quad (17)$$

$$I'_z = M_{uF}\,a^2 + M_{uR}\,b^2 \quad (18\text{-}E)$$

$$I'_z = M_{uF}\,(a^2 + \frac{T_F^2}{4}) + M_{uR}\,b^2 \quad (18\text{-}F)$$

$$I'_z = M_{uF}\left(a^2 + \frac{T_F^2}{4}\right) + M_{uR}\left(b^2 + \frac{T_R^2}{4}\right) \quad (18\text{-}G)$$

$$I'_{xz} = M_{uF}\,a\,z_F - M_{uR}\,b\,z_R \quad (19)$$

$$\gamma_1 = M_{uF}\,a - M_{uR}\,b \quad (20)$$

$$\gamma_2 = M_{uF}\, z_F + M_{uR}\, z_R \qquad (21)$$

$$\gamma_3 = \gamma_2 \qquad (22)$$

2.3 Vehicle Attitude and Position

The Euler angles and X, Y, Z coordinates in fixed space of the sprung mass are computed by the following equations:

$$\phi = \int_0^t (p + r\theta)\, dt + \phi(o) \qquad (23)$$

$$\theta = \int_0^t (q - r\phi)\, dt + \theta(o) \qquad (24)$$

$$\Psi = \int_0^t (r + q\phi)\, dt + \Psi(o) \qquad (25)$$

$$X = \int_0^t (u \cos \Psi - v \sin \Psi)\, dt + X(o) \qquad (26)$$

$$Y = \int_0^t (u \sin \Psi + v \cos \Psi)\, dt + Y(o) \qquad (27)$$

$$Z = \int_0^t (-u\theta + v\phi + w)\, dt + Z(o) \qquad (28)$$

2.4 Suspension Force

The suspension force includes the following effects: weight component; coulomb friction; spring force; shock absorber viscous damping; auxiliary roll stiffness; antipitch and antiroll forces.

2.4.1 Solid Front Axle

The suspension force effective at the front spring location can be expressed as:

$$S_i = F_{sWF} - F_{1Fi} - F_{2Fi} - F_{3Fi} + F_{4Fi} + F_{APFi} + F_{ARFi} \tag{29-A}$$

with i = 1, 2

where the individual contributions are as follows:

Static component of the sprung mass weight

$$F_{sWF} = \frac{b}{2(a + b)} M_s g \tag{30-A}$$

Coulomb friction

$$F_{1Fi} = C'_{Fi} \operatorname{sgn} \dot{\zeta}_i \tag{31-A}$$

Suspension force due to spring deflection and suspension bump stops impact is:

$$F_{2Fi} = K_{Fi} \zeta_i + F_{BSi} \tag{32-A}$$

and

$$F_{BSi} = F(\zeta_{Si}) \tag{33-A}$$

where $F(\zeta_{Si})$ is a digital function which is the difference between the linear analog value and the actual front spring characteristic.

The suspension deflection measured at the spring location from the position of static equilibrium at no-load condition is

$$\zeta_{Si} = \zeta_i + \zeta_{FIN} \tag{34-A}$$

Viscous damping force

$$\begin{aligned} F_{3Fi} &= C_{F1}\,\dot{\zeta}_i + (C_{F2} - C_{F1})\,\dot{\zeta}_{FC} && \text{for } \dot{\zeta}_i < \dot{\zeta}_{FC} \\ &= C_{F2}\,\dot{\zeta}_i && \text{for } \dot{\zeta}_{FC} \le \dot{\zeta}_i < 0 \\ &= C_{F3}\,\dot{\zeta}_i && \text{for } 0 \le \dot{\zeta}_i \le \dot{\zeta}_{FE} \\ &= C_{F4}\,\dot{\zeta}_i - (C_{F4} - C_{F3})\,\dot{\zeta}_{FE} && \text{for } \dot{\zeta}_i > \dot{\zeta}_{FE} \end{aligned} \tag{35-A}$$

Suspension force due to auxiliary roll stiffness

$$F_{4Fi} = (-1)^i \frac{R_F \phi_F}{T_{SF}} \tag{36-A}$$

Antipitch force

$$F_{APFi} = (P_{F0} + P_{F1}\,\zeta_i' + P_{F2}\,\zeta_i'^2)\;F_{xui} \tag{37-A}$$

Antiroll force

$$F_{ARFi} = (R_{F0} + R_{F1}\,\zeta_i' + R_{F2}\,\zeta_i'^2)\;F_{yui} \tag{38-A}$$

For these expressions, the suspension deflections relative to the vehicle from the position of static equilibrium, measured at the right (i=1) and left (i=2) spring location of the front axle, respectively, are evaluated as:

$$\zeta_i = \delta_F - (-1)^i\,\frac{T_{SF}}{2}\,\phi_F \tag{39-A}$$

$$\dot{\zeta}_i = \dot{\delta}_F - (-1)^i\,\frac{T_{SF}}{2}\,\dot{\phi}_F \tag{40-A}$$

while the suspension deflection of the center of the front wheel of the front axle is

$$\zeta_i' = \delta_F - (-1)^i\,\frac{T_F}{2}\,\phi_F \tag{41-A}$$

or

$$\zeta_i' = \zeta_i + (-1)^i\left(\frac{T_{SF} - T_F}{2}\right)\phi_F \tag{42-A}$$

2.4.2 Solid Rear Axle

For the rear suspension, the suspension force effective at the rear spring location can be written as:

$$S_i = F_{sWR} - F_{1Ri} - F_{2Ri} - F_{3Ri} + F_{4Ri} + F_{APRi} + F_{ARRi} \tag{29-B}$$

with i = 3, 4

where the individual contributions are as follows:

Static component of the sprung mass weight

$$F_{sWR} = \frac{a}{2(a + b)} M_s g \tag{30-B}$$

Coulomb friction

$$F_{1Ri} = C'_{Ri} \operatorname{sgn} \dot{\zeta}_i \tag{31-B}$$

Suspension force due to spring deflection and suspension bump stop stop impact is:

$$F_{2Ri} = K_{Ri} \zeta_i + F_{BSi} \tag{32-B}$$

and

$$F_{BSi} = F(\zeta_{Si}) \tag{33-B}$$

where $F(\zeta_{Si})$ is a digital function which is the difference between the linear analog value and the actual rear spring characteristics.

The suspension deflection measured at the spring location from the position of static equilibrium at no-load condition is

$$\zeta_{Si} = \zeta_i + \zeta_{RIN} \tag{34-B}$$

Viscous damping force

$$\begin{aligned}
F_{3Ri} &= C_{R1}\,\dot{\zeta}_i + (C_{R2} - C_{R1})\,\dot{\zeta}_{RC} && \text{for } \dot{\zeta}_i < \dot{\zeta}_{RC} \\
&= C_{R2}\,\dot{\zeta}_i && \text{for } \dot{\zeta}_{RC} \leqq \dot{\zeta}_i < 0 \\
&= C_{R3}\,\dot{\zeta}_i && \text{for } 0 \leqq \dot{\zeta}_i \leqq \dot{\zeta}_{RE} \\
&= C_{R4}\,\dot{\zeta}_i - (C_{R4} - C_{R3})\,\dot{\zeta}_{RE} && \text{for } \dot{\zeta}_i > \dot{\zeta}_{RE}
\end{aligned} \tag{35-B}$$

Suspension force due to auxiliary roll stiffness

$$F_{4Ri} = (-1)^i \frac{R_R \phi_R}{T_{SR}} \tag{36-B}$$

Antipitch force

$$F_{APRi} = (P_{R0} + P_{R1}\,\zeta_i' + P_{R2}\,\zeta_i'^2)\,F_{xui} \tag{37-B}$$

Antiroll force

$$F_{ARRi} = (R_{R0} + R_{R1}\,\zeta_i' + R_{R2}\,\zeta_i'^2)\,F_{yui} \tag{38-B}$$

For these expressions, the suspension deflections relative to the vehicle from the position of static equilibrium, measured at the right (i = 3) and left (i = 4) spring location of the rear axle, respectively, are evaluated as:

$$\zeta_i = \delta_R - (-1)^i \frac{T_{SR}}{2} \phi_R \tag{39-B}$$

$$\dot{\zeta}_i = \dot{\delta}_R - (-1)^i \frac{T_{SR}}{2} \dot{\phi}_R \tag{40-B}$$

while the suspension deflection of the center of the rear wheel of the rear axle is

$$\zeta_i' = \delta_R - (-1)^i \frac{T_R}{2} \phi_R \tag{41-B}$$

or

$$\zeta_i' = \zeta_i + (-1)^i \left(\frac{T_{SR} - T_R}{2}\right) \phi_R \tag{42-B}$$

2.4.3 Independent Front Suspension

The suspension forces S_i are effective at wheel i

$$S_i = F_{sWF} - F_{1Fi} - F_{2Fi} - F_{3Fi}$$

$$+ F_{4Fi} + F_{APFi} + F_{ARFi} \tag{29-C}$$

with i = 1,2

The static component of the sprung mass weight at the front wheel is

$$F_{sWF} = \frac{b}{2(a+b)} M_{sg} \tag{30-C}$$

The Coulomb friction force effective at wheel i is given by

$$F_{1Fi} = C'_{Fi} \operatorname{sgn} \dot{\delta}_i \tag{31-C}$$

The suspension force F_{2Fi} produced by deflection of the spring is

$$F_{2Fi} = K_{Fi} \delta_i + F_{BSi} \tag{32-C}$$

$$F_{BSi} = F(\delta_{Si}) \tag{33-C}$$

where $F(\delta_{Si})$ is a digital function which is the difference between the analog value and the actual spring characteristic.

δ_{Si} denotes the suspension deflection from the position of static equilibrium at no-load condition as

$$\delta_{Si} = \delta_i + \delta_{FIN} \tag{34-C}$$

The viscous damping force F_{3Fi} is expressed as

$$F_{3Fi} = C_{F1} \dot{\delta}_i + (C_{F2} - C_{F1}) \dot{\delta}_{FC} \qquad \text{for } \dot{\delta}_i < \dot{\delta}_{FC}$$

$$= C_{F2} \dot{\delta}_i \qquad \text{for } \dot{\delta}_{FC} \leqq \dot{\delta}_i < 0$$

$$= C_{F3}\ \dot{\delta}_i \qquad \text{for } 0 \leqq \dot{\delta}_i \leqq \dot{\delta}_{FE}$$

$$= C_{F4}\ \dot{\delta}_i - (C_{F4} - C_{F3})\,\dot{\delta}_{FE} \qquad \text{for } \dot{\delta}_i > \dot{\delta}_{FE} \tag{35-C}$$

where C_{Fk} denotes the slope of the segments (k=1 to 4), and $\dot{\delta}_{FC}$ and $\dot{\delta}_{FE}$ are the abscissa of the break points for compression and extension, respectively.

The suspension force F_{4Fi} due to auxiliary roll stiffness is

$$F_{4Fi} = (-1)^i\ \frac{R_F\ (\delta_1 - \delta_2)}{T_F^{\ 2}} \tag{36-C}$$

The antipitch force at wheel i is represented by the expression

$$F_{APFi} = (P_{F0} + P_{F1}\ \delta_i + P_{F2}\ \delta_i^{\ 2})\ F_{xui} \tag{37-C}$$

where F_{xui} is the component of the tire force on wheel i in the x-direction in the vehicle axis system.

The antiroll force at wheel i is expressed as

$$F_{ARFi} = (R_{F0} + R_{F1}\ \delta_i + R_{F2}\ \delta_i^{\ 2})\ F_{yui} \tag{38-C}$$

where F_{yui} is the component of the tire force on wheel i along the vehicle y-axis.

2.4.4 Independent Rear Suspension

Similarly, the suspension force effective at wheel i can be expressed as

$$S_i = F_{sWR} - F_{1Ri} - F_{2Ri} - F_{3Ri}$$

$$+ F_{4Ri} + F_{APRi} + F_{ARRi} \tag{29-D}$$

with i = 3,4
where the individual contributions are as follows:

Static component of the spring mass weight

$$F_{sWR} = \frac{a}{2(a + b)} M_s g \tag{30-D}$$

Coulomb friction

$$F_{1Ri} = C'_{Ri} \text{ sgn } \dot{\delta}_i \tag{31-D}$$

Suspension force due to spring deflection and suspension bumb stop impact is:

$$F_{2Ri} = K_{Ri} \delta_i + F_{BSi} \tag{32-D}$$

and

$$F_{BSi} = F(\delta_{Si}) \tag{33-D}$$

where $F(\delta_{Si})$ is a digital function which is the difference between the linear analog value and the actual rear spring characteristic.

and

$$\delta_{Si} = \delta_i + \delta_{RIN} \tag{34-D}$$

Viscous damping force

$$\begin{aligned} F_{3Ri} &= C_{R1}\,\dot{\delta}_i + (C_{R2} - C_{R1})\,\dot{\delta}_{RC} && \text{for } \dot{\delta}_i < \dot{\delta}_{RC} \\ &= C_{R2}\,\dot{\delta}_i && \text{for } \dot{\delta}_{RC} \leqq \dot{\delta}_i < 0 \\ &= C_{R3}\,\dot{\delta}_i && \text{for } 0 \leqq \dot{\delta}_i \leqq \dot{\delta}_{RE} \\ &= C_{R4}\,\dot{\delta}_i - (C_{R4} - C_{R3})\,\dot{\delta}_{RE} && \text{for } \dot{\delta}_i > \dot{\delta}_{RE} \end{aligned} \tag{35-D}$$

Suspension force due to auxiliary roll stiffness

$$F_{4Ri} = (-1)^i \frac{R_R\,(\delta_3 - \delta_4)}{T_R^{\,2}} \tag{36-D}$$

Antipitch force

$$F_{APRi} = (P_{R0} + P_{R1}\,\delta_i + P_{R2}\,\delta_i^{\,2})\,F_{xui} \tag{37-D}$$

Antiroll force

$$F_{ARRi} = (P_{R0} + R_{R1}\,\delta_i + R_{R2}\,\delta_i^{\,2})\,F_{yui} \tag{38-D}$$

2.5 Wheel Orientation

The orientations of the wheels with respect to the sprung mass are defined by the following equations:

Camber angles at wheel i

$$\phi_1 = \phi_F + \Delta\phi_1 \tag{43-A}$$

$$\phi_2 = \phi_F + \Delta\phi_2 \tag{44-A}$$

$$\phi_3 = \phi_R \tag{45-B}$$

$$\phi_4 = \phi_R \tag{46-B}$$

$$\phi_1 = \sum_{i=o}^{5} C_{i_F} \delta_{S1}^{i} + \Delta\phi_1 \operatorname{sgn} F_{S1} \tag{43-C}$$

$$\phi_2 = -\sum_{i=o}^{5} C_{iF} \delta_{S2}^{i} + \Delta\phi_2 \operatorname{sgn} F_{S2} \tag{44-C}$$

$$\phi_3 = \sum_{i=o}^{5} C_{iR} \delta_{S3}^{i} \tag{45-D}$$

$$\phi_4 = -\sum_{i=o}^{5} C_{iR} \delta_{S4}^{i} \tag{46-D}$$

Steer angles at wheel i

$$\Psi_1 = \delta_{FW1} - K_{FS}\, \phi_F + \Delta\Psi_1 \tag{47-A}$$

$$\Psi_2 = \delta_{FW2} - K_{FS}\, \phi_F + \Delta\Psi_2 \tag{48-A}$$

$$\Psi_3 = K_{RS}\, \phi_R + K_{SR}\, M_{ZR3} \tag{49-B}$$

$$\Psi_4 = K_{RS}\, \phi_R + K_{SR}\, M_{ZR4} \tag{50-B}$$

$$\Psi_1 = \delta_{FW1} + \sum_{i=o}^{5} D_{iF}\, \delta_{S1}^{i} + \Delta\Psi_1 \tag{47-C}$$

$$\Psi_2 = \delta_{FW2} - \sum_{i=o}^{5} D_{iF}\, \delta_{S2}^{i} + \Delta\Psi_2 \tag{48-C}$$

$$\Psi_3 = \sum_{i=o}^{5} D_{iR}\, \delta_{S3}^{i} + K_{SR}\, M_{ZR3} \tag{49-D}$$

$$\Psi_4 = -\sum_{i=o}^{5} D_{iR}\, \delta_{S4}^{i} + K_{SR}\, M_{ZR4} \tag{50-D}$$

Caster angles of the front wheels

$$\theta_{S1} = \sum_{i=o}^{5} E_{iF}\, \delta_{S1}^{i} + \Delta\theta_1 \tag{51}$$

$$\theta_{S2} = \sum_{i=o}^{5} E_{iF}\, \delta_{S2}^{i} + \Delta\theta_2 \tag{52}$$

2.6 Resultant Forces and Moments

The resultant tire, suspension, and aerodynamic forces and moments required for the equations of motion are given below:

Tire forces:

$$F_{xui} = F_{Ri}\ \theta + F_{Ci}\ \mathrm{COS}\ \Psi_i - F_{Si}\ \mathrm{SIN}\ \Psi_i \tag{53}$$

$$F_{yui} = -F_{Ri}\ \phi + F_{Ci}\ \mathrm{SIN}\ \Psi_i + F_{Si}\ \mathrm{COS}\ \Psi_i \tag{54}$$

$$F_{zui} = -F_{Ri} \tag{55}$$

$$\Sigma\ F_{xu} = \sum_{i=1}^{4} F_{xui} \tag{56}$$

$$\Sigma\ F_{yu} = \sum_{i=1}^{4} F_{yui} \tag{57}$$

$$\Sigma\ F_{zu} = \sum_{i=1}^{4} F_{zui} \tag{58}$$

Aerodynamic forces:

Cross Wind Disturbance

$$u_r = u - v_{yw} \sin \psi \tag{59}$$

$$v_r = v - v_{yw} \cos \psi \tag{60}$$

$$w_r = w \tag{61}$$

$$\overline{p} = (p - \omega_{xw} \cos \psi + \omega_{zw}\ \theta) \frac{\ell}{u_r} \tag{62}$$

$$\overline{q} = (q + \omega_{xw} \sin \psi - \omega_{zw} \phi) \frac{\ell}{u_r} \tag{63}$$

$$\overline{r} = (r - \omega_{zw}) \frac{\ell}{u_r} \tag{64}$$

$$V_{CW} = \sqrt{u_r^2 + v_r^2 + w_r^2} \tag{65}$$

$$\alpha = \tan^{-1} \left(\frac{w_r}{u_r} \right) \tag{66}$$

$$\tau = \left| \sin^{-1} \left(\frac{v_r}{V_{CW}} \right) \right| \tag{67}$$

$$q_a = \frac{1}{2} \rho_a V_{CW}^2 \tag{68}$$

$$\Sigma F_{xs} = (C_X + \Delta C_X) q_a S_f \tag{69}$$

$$\Sigma F_{ys} = (C_Y + C_{Y_p} \overline{p} + C_{Y_r} \overline{r}) q_a S_f \tag{70}$$

$$\Sigma F_{zs} = (C_Z + C_{Z_\alpha} \alpha + C_{Z_q} \overline{q}) q_a S_f \tag{71}$$

Tire moments:

$$\begin{aligned} \Sigma N_{\phi u} = {} & (S_2 - S_1) \frac{T_{SF}}{2} + (S_4 - S_3) \frac{T_{SR}}{2} \\ & - (F_{yu1} + F_{yu2}) (z_F + \delta_F) \\ & - (F_{yu3} + F_{yu4}) (z_R + \delta_R) \end{aligned} \tag{72-E}$$

$$\begin{aligned}\Sigma N_{\theta u} = {} & (S_1 + S_2)a - (S_3 + S_4)b \\ & + F_{xu1}(z_F + \delta_F + \frac{T_F}{2}\phi_F + h_1) \\ & + F_{xu2}(z_F + \delta_F - \frac{T_F}{2}\phi_F + h_2) \\ & + F_{xu3}(z_R + \delta_R + \frac{T_R}{2}\phi_R + h_3) \\ & + F_{xu4}(z_R + \delta_R - \frac{T_R}{2}\phi_R + h_4) \end{aligned} \quad (73\text{-E})$$

$$\begin{aligned}\Sigma N_{\phi u} = {} & (S_2 - S_1)\frac{T_F}{2} + (S_4 - S_3)\frac{T_{SR}}{2} \\ & - F_{yu1}(z_F + \delta_1 + h_1 - H_{FC}) \\ & - F_{yu2}(z_F + \delta_2 + h_2 - H_{FC}) \\ & - (F_{yu3} + F_{yu4})(z_R + \delta_R) + \sum_{i=1}^{2} M_{XFi} \end{aligned} \quad (72\text{-F})$$

$$\begin{aligned}\Sigma N_{\theta u} = {} & (S_1 + S_2)a - (S_3 + S_4)b \\ & + F_{xu1}(z_F + \delta_1 + h_1) + F_{xu2}(z_F + \delta_2 + h_2) \\ & + F_{xu3}(z_R + \delta_R + \frac{T_R}{2}\phi_R + h_3) \\ & + F_{xu4}(z_R + \delta_R - \frac{T_R}{2}\phi_R + h_4) \end{aligned} \quad (73\text{-F})$$

$$\Sigma N_{\phi u} = (S_2 - S_1)\frac{T_F}{2} + (S_4 - S_3)\frac{T_R}{2}$$

$$-F_{yu1}(z_F + \delta_1 + h_1 - H_{FC})$$

$$-F_{yu2}(z_F + \delta_2 + h_2 - H_{FC})$$

$$-F_{yu3}(z_R + \delta_3 + h_3 - H_{RC})$$

$$-F_{yu4}(z_R + \delta_4 + h_4 - H_{RC})$$

$$+\sum_{i=1}^{2} M_{XFi} + \sum_{i=3}^{4} M_{XRi} \qquad (72\text{-G})$$

$$\Sigma N_{\theta u} = (S_1 + S_2)a - (S_3 + S_4)b$$

$$+ F_{xu1}(z_F + \delta_1 + h_1) + F_{xu2}(z_F + \delta_2 + h_2)$$

$$+ F_{xu3}(z_R + \delta_3 + h_3) + F_{xu4}(z_R + \delta_4 + h_4) \qquad (73\text{-G})$$

$$\Sigma N_{\phi F} = (S_1 - S_2)\frac{T_{SF}}{2} + F_{zu1}\left(\frac{T_F}{2} - h_1\phi_F\right) - F_{zu2}\left(\frac{T_F}{2} + h_2\phi_F\right)$$

$$-F_{yu1}\left(\frac{T_F}{2}\phi_F + h_1\right) - F_{yu2}\left(-\frac{T_F}{2}\phi_F + h_2\right) + \sum_{i=1}^{2} M_{XFi} \qquad (74\text{-A})$$

$$\Sigma N_{\Psi u} = (F_{yu1} + F_{yu2})a - (F_{yu3} + F_{yu4})b$$

$$+ (F_{xu2} - F_{xu1}) \frac{T_F}{2} + (F_{xu4} - F_{xu3}) \frac{T_R}{2}$$

$$+ \sum_{i=1}^{2} M_{ZFi} + \sum_{i=3}^{4} M_{ZRi} \tag{75}$$

$$\Sigma N_{\phi R} = (S_3 - S_4) \frac{T_{SR}}{2} + F_{zu3}\left(\frac{T_R}{2} - h_3\phi_R\right) - F_{zu4}\left(\frac{T_R}{2} + h_4\phi_R\right)$$

$$- F_{yu3}\left(\frac{T_R}{2} \phi_R + h_3\right) - F_{yu4} \left(- \frac{T_R}{2} \phi_R + h_4\right)$$

$$+ \sum_{i=3}^{4} M_{XRi} \tag{76-B}$$

where M_{ZFi}, M_{ZRi}, M_{XFi} and M_{XRi} are the front and rear wheel aligning torques and overturning moments, respectively.

Aerodynamic moments:

$$d_{CG} = a - \frac{\ell}{2} \tag{77}$$

$$C_L' = \frac{\ell_v}{\ell} C_L - \frac{Z_{(o)}}{\ell} C_Y \tag{78}$$

$$C_M' = \frac{\ell_v}{\ell} C_M - \frac{d_{CG}}{\ell} C_Z + \frac{Z_{(o)}}{\ell} C_X \tag{79}$$

$$C_N' = \frac{\ell_v}{\ell} C_N + \frac{d_{CG}}{\ell} C_Y \tag{80}$$

$$\Sigma N_{\phi s} = (C_L' + C_{\ell_p} \bar{p} + C_{\ell_r} \bar{r}) q_a S_f \ell \tag{81}$$

$$\Sigma N_{\theta s} = (C_M' + C_{m_\alpha} \alpha + C_{m_q} \bar{q}) q_a S_f \ell \tag{82}$$

$$\Sigma N_{\psi s} = (C_N' + C_{n_p} \bar{p} + C_{n_r} \bar{r}) q_a S_f \ell \tag{83}$$

2.7 Radial Tire Force and Rolling Radius

The radial tire forces and the rolling radii of the tires are computed by the following equations:

$$F_{Ri} = K_{Ti} (R_w - h_i) \tag{84}$$

where

$$h_i = - Z_i;\ i = 1, 2, 3, 4 \qquad h_i \leq R_w$$

$$h_i = R_w \qquad h_i > R_w \tag{85}$$

$$Z_1 = Z - a\theta + z_F + \delta_F + (\phi + \phi_F) \frac{T_F}{2} + Z_{S1} \tag{86-A}$$

$$Z_2 = Z - a\theta + z_F + \delta_F - (\phi + \phi_F) \frac{T_F}{2} + Z_{S2} \tag{87-A}$$

$$Z_3 = Z + b\,\theta + z_R + \delta_R + (\phi + \phi_R)\,\frac{T_R}{2} + Z_{S3} \tag{88-B}$$

$$Z_4 = Z + b\,\theta + z_R + \delta_R - (\phi + \phi_R)\,\frac{T_R}{2} + Z_{S4} \tag{89-B}$$

$$Z_1 = Z - a\,\theta + \frac{T_F}{2}\,\phi + z_F + \delta_1 + Z_{S1} \tag{86-C}$$

$$Z_2 = Z - a\,\theta - \frac{T_F}{2}\,\phi + z_F + \delta_2 + Z_{S2} \tag{87-C}$$

$$Z_3 = Z + b\,\theta + \frac{T_R}{2}\,\phi + z_R + \delta_3 + Z_{S3} \tag{88-D}$$

$$Z_4 = Z + b\,\theta - \frac{T_R}{2}\,\phi + z_R + \delta_4 + Z_{S4} \tag{89-D}$$

and the initial tire loading and orientation are as shown below:

$$\theta_{(0)} = \frac{\left[h_{1(0)} - h_{3(0)}\right] + \left[z_F - z_R\right]}{a + b} \tag{90}$$

$$h_{1(0)} = h_{2(0)} = R_w - \frac{g}{2K_{T1}}\left[M_{UF} + \left(\frac{b}{a+b}\right) M_S\right] \tag{91}$$

$$h_{3(0)} = h_{4(0)} = R_W - \frac{g}{2K_{T3}} \left[M_{UR} + \left(\frac{a}{a+b}\right) M_S \right] \tag{92}$$

$$Z_{(0)} = \frac{b\left[h_{1(0)} + z_F\right] + a\left[h_{3(0)} + z_R\right]}{a+b} + Z_{BIAS} \tag{93}$$

Wheel lift-off indication is provided by

$$Z_{MXi} = (R_W - h_i) \qquad i = 1, 2, 3, 4 \tag{94}$$

where

$Z_{MXi} > 0$ wheel i in contact with tire-terrain patch

$Z_{MXi} \leq 0$ wheel i not in contact with tire-terrain patch

2.8 Tire Circumferential Force

The circumferential tire forces for both driving and braking are defined below:

$$F_{Ci} = - \mu_i' F_{Ri} \tag{95}$$

2.9 Circumferential Friction Coefficient

The circumferential friction coefficient equations are shown below:

$$\mu_i' = m_{2i}\ (\mathrm{SLIP})_i + \mu_{0i} \quad \text{for } (\mathrm{SLIP})_i > SI_i$$

$$= m_{1i}\ (\mathrm{SLIP})_i \quad \text{for } (\mathrm{SLIP})_i \leqq SI_i \tag{96}$$

Computation of the slopes for the μ_i' curve is performed by the following equations:

front wheels:

$$\mu'_{SF} = \mu_{SF} \left| \cos(\beta_i) \right| \qquad i = 1,2 \tag{97}$$

$$\mu_{PF} = P_{BF1} + P_{BF2}\ F_{Ri} \tag{98}$$

$$SN_i = (SN)_{S0}/(SN)_T \tag{99}$$

$$m_{1i} = \left(\frac{\mu_{PF}}{SI_i}\right) \left(1.0 - 57.3\ B_c \left|\beta_i + \beta_i'\right|\right) SN_i \qquad \text{for } m_{1i} \geqq \frac{\mu'_{SF}}{SI_i} SN_i$$

$$= \left(\frac{\mu'_{SF}}{SI_i}\right) SN_i \qquad \text{for } m_{1i} < \frac{\mu'_{SF}}{SI_i} SN_i \tag{100}$$

$$m_{2i} = \left[\frac{\mu'_{SF} - \mu_{PF}\ (1.0 - 57.3\ B_c\ |\beta \quad \beta'_i|}{(1.0 - SI_i)}\right] SN_i \quad \text{for } m_{1i} \geq \frac{\mu'_{SF}}{SI_i} SN_i$$

$$= 0.0 \qquad \text{for } m_{1i} < \frac{\mu'_{SF}}{SI_i} SN_i \tag{101}$$

$$\mu_{1i} = \mu'_{SF}\ SNi \tag{102}$$

$$\mu_{0i} = \mu_{1i} - m_{2i} \tag{103}$$

Rear wheels:

$$\mu'_{SR} = \mu_{SR}\ |\cos(\beta_i)| \qquad i = 3,4 \tag{104}$$

$$\mu_{PR} = P_{BR1} + P_{BR2}\ F_{Ri} \tag{105}$$

$$SN_i = (SN)_{S0}/(SN)_T \tag{106}$$

$$m_{1i} = \left(\frac{\mu_{PR}}{SI_i}\right)(1.0 - 57.3\ B_c\ |\beta_i + \beta'_i|)\ SN_i \qquad \text{for } m_{1i} \geq \frac{\mu'_{SR}}{SI_i} SN_i$$

$$= \left(\frac{\mu'_{SR}}{SI_i}\right) SN_i \qquad \text{for } m_{1i} < \frac{\mu'_{SR}}{SI_i} SN_i \tag{107}$$

$$m_{2i} = \left[\frac{\mu'_{SR} - \mu_{PR}\ (1.0 - 57.3\ B_c\ |\beta_i + \beta'_i|)}{(1.0 - SI_i)}\right] SN_i \quad \text{for } m_{1i} \geq \frac{\mu'_{SR}}{SI_i} SN_i$$

$$= 0.0 \qquad \text{for } m_{1i} < \frac{\mu'_{SR}}{SI_i} SN_i \tag{108}$$

$$\mu_{1i} = \mu'_{SR}\ SN_i \tag{109}$$

$$\mu_{0i} = \mu_{1i} - m_{2i} \tag{110}$$

2.10 Wheel Slip

Computation of circumferential wheel slip is performed by the following equations:

$$\begin{aligned} (SLIP)_i &= 1 \qquad \text{for } \xi_i > 1 \\ &= \xi_i \qquad \text{for } -1 \leqq \xi_i \leqq 1 \\ &= -1 \qquad \text{for } \xi_i < -1 \end{aligned} \tag{111}$$

where

$$\xi_i = 1 - \frac{\omega_i\ h_i}{u_{Gi}\ COS\ \Psi_i + v_{Gi}\ SIN\ \Psi_i} \tag{112}$$

2.11 Wheel Rotational Equations

The wheel rotational equations required to compute wheel slip are presented below:

$$\begin{aligned} &(I_{WF} + \frac{1}{4}\ I_{DF}\ \overline{AR}_F^{\,2})\ \dot{\omega}_1 + (\frac{1}{4}\ I_{DF}\ \overline{AR}_F^{\,2})\dot{\omega}_2 \\ &\quad = -\ F_{C1}\ h_1 + \overline{TQ}_1 \end{aligned} \tag{113}$$

$$(I_{WF} + \frac{1}{4} I_{DF} \overline{AR}_F^{\,2})\ \dot{\omega}_2 + (\frac{1}{4} I_{DF} \overline{AR}_F^{\,2})\dot{\omega}_1$$

$$= - F_{C2}\ h_2 + \overline{TQ}_2 \tag{114}$$

$$(I_{WR} + \frac{1}{4} I_{DR} \overline{AR}_R^{\,2})\ \dot{\omega}_3 + (\frac{1}{4} I_{DR} \overline{AR}_R^{\,2})\dot{\omega}_4$$

$$= - F_{C3}\ h_3 + \overline{TQ}_3 \tag{115}$$

$$(I_{WR} + \frac{1}{4} I_{DR} \overline{AR}_R^{\,2})\ \dot{\omega}_4 + (\frac{1}{4} I_{DR} \overline{AR}_R^{\,2})\dot{\omega}_3$$

$$= -F_{C4}\ h_4 + \overline{TQ}_4 \tag{116}$$

where

$$\omega_i = \omega_i(0) + \int_o^t \dot{\omega}_i\ dt \tag{117}$$

For $(SLIP)_i = 0$ at $t = 0$

$$\omega_i(0) = \frac{u_{Gi}(0)\ \mathrm{COS}\ \Psi_i(0) + v_{Gi}\ (0)\ \mathrm{SIN}\ \Psi_i(0)}{h_i(0)} \tag{118}$$

$$\overline{TQ}_1 = (1 - \lambda_D)\ \left(\frac{\overline{AR}_F}{2}\right) \overline{TQ}_{DF} + \lambda_{B1}\ \overline{TQ}_{B1} \tag{119}$$

$$\overline{TQ}_2 = (1 - \lambda_D)\ \left(\frac{\overline{AR}_F}{2}\right) \overline{TQ}_{DF} + \lambda_{B2}\ \overline{TQ}_{B2} \tag{120}$$

$$\overline{TQ}_3 = \lambda_D \left(\frac{\overline{AR}_R}{2}\right) \overline{TQ}_{DR} + \lambda_{B3} \overline{TQ}_{B3} \tag{121}$$

$$\overline{TQ}_4 = \lambda_D \left(\frac{\overline{AR}_R}{2}\right) \overline{TQ}_{DR} + \lambda_{B4} \overline{TQ}_{B4} \tag{122}$$

2.12 Brake and Drive Torques

The drive torques generated to maintain a constant velocity are computed by:

$$\overline{TQ}_D = K_{TQ} (V_C - u), \text{ for } \overline{TQ}_D \leq TQ_{D_{MAX}}$$

$$= TQ_{D_{MAX}}, \text{ otherwise} \tag{123}$$

where V_C is the desired velocity.

Values of 1000 lb in./in./sec. and 6000 lb in. were assigned to K_{TQ} and $TQ_{D_{MAX}}$ respectively. When braking is investigated, the drive torque is zero and the brake torque magnitudes are determined from input data functions.

$$\overline{TQ}_{B1} = \overline{TQ}_{B2} = FF(PFL), \text{ lb-in.} \tag{124}$$

$$\overline{TQ}_{B3} = \overline{TQ}_{B4} = FR(PFL), \text{ lb-in.} \tag{125}$$

where PFL is an input value for brake-line pressure.

2.13 Tire Side Force

The nonlinear tire side forces are computed using the following equations:

$$F_{Si} = F_{Ri} \left\{ |\mu_{yi}\, g(\bar{\beta}_i)| - [|\mu_{yi}\, g(\bar{\beta}_i)| - \mu_{SF}\, |\mathrm{SIN}\,(\beta_i)|\, SN_i]\, F_i \right\} \mathrm{SGN}\, g(\bar{\beta}_i) \qquad i = 1,2 \tag{126}$$

$$F_{Si} = F_{Ri} \left\{ |\mu_{yi}\, g(\bar{\beta}_i)| - [|\mu_{yi}\, g(\bar{\beta}_i)| - \mu_{SR}\, |\mathrm{SIN}\,(\beta_i)|\, SN_i]\, F_i \right\} \mathrm{SGN}\, g(\bar{\beta}_i) \qquad i = 3,4 \tag{127}$$

2.14 Tire Side Force Friction Coefficient

The side force coefficient of friction is defined below:

$$\mu_{yi} = (B_{1F}\, F_{Ri} + B_{2F}\, C_{vi} + B_{3F} + B_{4F}\, F_{Ri}^{\ 2})\ SN_i \qquad i = 1,2 \tag{128}$$

$$\mu_{yi} = (B_{1R}\, F_{Ri} + B_{2R}\, C_{vi} + B_{3R} + B_{4R}\, F_{Ri}^{\ 2})\ SN_i \qquad i = 3,4 \tag{129}$$

and

$$C_{vi} = \sqrt{u_{Gi}^{\ 2} + v_{Gi}^{\ 2}} \tag{130}$$

2.15 Velocities of the Tire Contact Points

The velocities of the tire contact points along the vehicle axes are computed by the following equations:

$$u_1 = u - \frac{T_F}{2} r + z_F\, q \qquad (131)$$

$$u_2 = u + \frac{T_F}{2} r + z_F\, q \qquad (132)$$

$$u_3 = u - \frac{T_R}{2} r + z_R\, q \qquad (133)$$

$$u_4 = u + \frac{T_R}{2} r + z_R\, q \qquad (134)$$

$$v_1 = v + ar - (z_F + h_1)p - h_1\, \dot{\phi}_F \qquad (135\text{-A})$$

$$v_2 = v + ar - (z_F + h_2)p - h_2\, \dot{\phi}_F \qquad (136\text{-A})$$

$$v_3 = v - br - (z_R + h_3)p - h_3\, \dot{\phi}_R \qquad (137\text{-B})$$

$$v_4 = v - br - (z_R + h_4)p - h_4\, \dot{\phi}_R \qquad (138\text{-B})$$

$$v_1 = v + ar - (z_F + h_1)p \qquad (135\text{-C})$$

$$v_2 = v + ar - (z_F + h_2)p \qquad (136\text{-C})$$

$$v_3 = v - br - (z_R + h_3)p \tag{137-D}$$

$$v_4 = v - br - (z_R + h_4)p \tag{138-D}$$

$$w_1 = w - aq + \dot{\delta}_F + (p + \dot{\phi}_F)\frac{T_F}{2} \tag{139-A}$$

$$w_2 = w - aq + \dot{\delta}_F - (p + \dot{\phi}_F)\frac{T_F}{2} \tag{140-A}$$

$$w_3 = w + bq + \dot{\delta}_R + (p + \dot{\phi}_R)\frac{T_R}{2} \tag{141-B}$$

$$w_4 = w + bq + \dot{\delta}_R - (p + \dot{\phi}_R)\frac{T_R}{2} \tag{142-B}$$

$$w_1 = w - aq + \frac{T_F}{2}p + \dot{\delta}_1 \tag{139-C}$$

$$w_2 = w - aq - \frac{T_F}{2}p + \dot{\delta}_2 \tag{140-C}$$

$$w_3 = w + bq + \dot{\delta}_3 + \frac{T_R}{2}p \tag{141-D}$$

$$w_4 = w + bq + \dot{\delta}_4 - \frac{T_R}{2}p \tag{142-D}$$

The wheel velocities in the ground plane are obtained by:

$$u_{Gi} = u_i + \theta w_i \tag{143}$$

$$v_{Gi} = v_i - \phi w_i \tag{144}$$

2.16 Combined Slip Angle and Camber Shaping Function

The dimensionless side force shaping function for slip angle and camber is as follows:

$$g(\bar{\beta}_i) = \bar{\beta}_i - \frac{1}{3}\bar{\beta}_i\,|\bar{\beta}_i| + \frac{1}{27}\bar{\beta}_i^{\,3} \quad \text{if } |\bar{\beta}_i| < 3 \tag{145}$$

$$= \frac{\bar{\beta}_i}{|\bar{\beta}_i|} \quad \text{if } |\bar{\beta}_i| \geqq 3 \qquad i = 1,2,3,4$$

For $F_{Ri} \leqq A\Omega_{TF} A_{2F}$, $\quad i = 1,2$

$$\bar{\beta}_i = \frac{A_{1F}\, F_{Ri}\, (F_{Ri} - A_{2F}) - A_{oF}\, A_{2F}}{A_{2F}\, \mu_{yi}\, F_{Ri}} (\beta_i + \beta_i') \tag{146}$$

$$\beta_i' = \frac{A_{2F}\, A_{3F}\, (A_{4F} - F_{Ri})\, F_{Ri}\, \phi_{CGi}}{A_{4F}\,|A_{1F}\, F_{Ri}\, (F_{Ri} - A_{2F}) - A_{oF}\, A_{2F}|} \tag{147}$$

If $F_{Ri} > A\Omega_{TF}\, A_{2F}$, $\quad i = 1,2$

$$\bar{\beta}_i = \frac{A_{1F}\, A_{2F}\, A\Omega_{TF}\, (A\Omega_{TF} - 1) - A_{oF}}{\mu_{yi}\, F_{Ri}} (\beta_i + \beta_i') \tag{148}$$

$$\beta_i' = \frac{A_{2F}\, A_{3F}\, A\Omega_{TF}\, (A_{4F} - A\Omega_{TF}\, A_{2F})\, \phi_{CGi}}{A_{4F}\,|A_{1F}\, A_{2F}\, A\Omega_{TF}\, (A\Omega_{TF} - 1) - A_{oF}|} \tag{149}$$

For $F_{Ri} \leqq A\Omega_{TR}\, A_{2R}$, $\qquad i = 3,4$

$$\overline{\beta}_i = \frac{A_{1R}\, F_{Ri}\, (F_{Ri} - A_{2R}) - A_{oR}\, A_{2R}}{A_{2R}\, \mu_{yi}\, F_{Ri}} (\beta_i + \beta_i') \tag{150}$$

$$\beta_i' = \frac{A_{2R}\, A_{3R}\, (A_{4R} - F_{Ri})\, F_{Ri}\, \phi_{CGi}}{A_{4R} \left| A_{1R}\, F_{Ri}\, (F_{Ri} - A_{2R}) - A_{oR}\, A_{2R} \right|} \tag{151}$$

If $F_{Ri} > A\Omega_{TR}\, A_{2R}$, $\qquad i = 3,4$

$$\overline{\beta}_i = \frac{A_{1R}\, A_{2R}\, A\Omega_{TR}\, (A\Omega_{TR} - 1) - A_{oR}}{\mu_{yi}\, F_{Ri}} (\beta_i + \beta_i') \tag{152}$$

$$\beta_i' = \frac{A_{2R}\, A_{3R}\, A\Omega_{TR}\, (A_{4R} - A\Omega_{TR}\, A_{2R})\, \phi_{CGi}}{A_{4R} \left| A_{1R}\, A_{2R}\, A\Omega_{TR}\, (A\Omega_{TR} - 1) - A_{oR} \right|} \tag{153}$$

2.17 Wheel Slip Angle

$$\beta_i = \tan^{-1} \left[\frac{v_{Gi}}{|u_{Gi}|} \right] - \Psi_i \,\mathrm{sgn}\, u_{Gi} \tag{154}$$

2.18 Wheel Camber with Respect to the Road

The camber angles of the wheels measured with respect to the road are given by:

$$\phi_{CGi} = \Delta\phi_1 \qquad i = 1,2 \qquad (155\text{-A})$$

$$\phi_{CGi} = 0 \qquad i = 3,4 \qquad (156\text{-B})$$

$$\phi_{CGi} = \theta \ \mathrm{SIN}\ \Psi_i + \phi \ \mathrm{COS}\ \Psi_i + \phi_i + K_{CF}\, F_{Si} \qquad i = 1,2 \qquad (155\text{-C})$$

$$\phi_{CGi} = \theta \ \mathrm{SIN}\ \Psi_i + \phi \ \mathrm{COS}\ \Psi_i + \phi_i + K_{CR}\, F_{Si} \qquad i = 3,4 \qquad (156\text{-D})$$

2.19 Wheel Slip Shaping Function

The dimensionless side force shaping function for circumferential slip is empirically derived.

$$F_i \left[(\mathrm{SLIP})_i \right] = \text{input table} \qquad (157)$$

F_i	$(\mathrm{SLIP})_i$ (%)
0.00	00.0
0.01	05.0
0.03	10.0
0.07	15.0
0.17	20.0
0.35	30.0
0.54	40.0
0.81	60.0
0.93	80.0
1.00	100.0

2.20 Tire Moments

The tire-road reaction moments acting about the kingpins are computed by the following equations:

$$M_{Ti} = F_{xui} \Big[\overline{PT}_i \text{ SIN } \Psi_i - y_{SAi} \text{ COS } \Psi_i + h_i \left(\phi_i \text{ COS } \Psi_i - \phi_{Si}\right)\Big] + F_{yui} \Big[-\overline{PT}_i \, KK_i \text{ COS } \Psi_i - y_{SAi} \text{ SIN } \Psi_i + h_i \left(\phi_i \text{ SIN } \Psi_i - \theta_{Si}\right)\Big] + F_{zui} \Big[-\overline{PT}_i \left(\phi_{Si} \text{ COS } \Psi_i + \theta_{Si} \text{ SIN } \Psi_1\right) + Y_{SAi} \left(\theta_{Si} \text{ COS } \Psi_i - \phi_{Si} \text{ SIN } \Psi_i\right) + h_i \left(\phi_{Si} \phi_i \text{ SIN } \Psi_i - \theta_{Si} \phi_i \text{ COS } \Psi_i\right)\Big] \qquad i = 1,2 \tag{158}$$

$$\phi_{S1} = \phi_{SA1} + \phi_1 \tag{159}$$

$$\phi_{S2} = \phi_{SA2} + \phi_2 \tag{160}$$

The tire aligning torques are defined as

$$M_{ZFi} = \left(A_{F1} F_{Ri} + A_{F2} |F_{Si}|\right) F_{Si} + A_{F3} F_{Ri} \left(|\phi_{CG_i}|\right)^{1/2} \qquad i = 1,2 \tag{161}$$

$$M_{ZRi} = \left(A_{R1} F_{Ri} + A_{R2} |F_{Si}|\right) F_{Si} + A_{R3} F_{Ri} \left(|\phi_{CGi}|\right)^{1/2} \qquad i = 3,4 \tag{162}$$

The tire overturning moments are defined as

$$M_{XFi} = O_{F0} + (O_{F1} + O_{F2}|\phi_{CGi}|)\ F_{Si}\ F_{Ri} + O_{F3}\ \phi_{CGi}\ F_{Ri} \qquad (163)$$

$$i = 1,2$$

$$M_{XRi} = O_{R0} + (O_{R1} + O_{R2}|\phi_{CGi}|)\ F_{Si}\ F_{Ri} + O_{R3}\ \phi_{CGi}\ F_{Ri} \qquad (164)$$

$$i = 3,4$$

2.21 Steering Equations

The steering equations are presented below:

$$(\dot{r} + \ddot{\delta}_{FWi})\ I_{FW} = -\ H_i\ \dot{\delta}_{FWi} + M_{Ti} - M_{SSi} + M_{ZFi} \qquad (165)$$

$$i = 1,2$$

$$M_{CR}\ \ddot{y}_{CR} = -C_{FCR} - C_{CR}\ \dot{y}_{CR} + \frac{T_P}{a_p} + \frac{M_{SS1}}{a_{L1}} + \frac{M_{SS2}}{a_{L2}} \qquad (166)$$

where $C_{FCR} = f(\dot{y}_{CR})$

conditions:

$$T_P = N_G \left\{K_{SC} \left[\left(\delta_{SW} - N_G\ \frac{Y_{CR}}{a_p}\right) - \frac{\varepsilon_{SP}}{2}\ \text{sgn}\left(\delta_{sw} - N_G\ \frac{Y_{CR}}{a_p}\right)\right]\right\}$$

if $\left|\delta_{SW} - N_G\ \frac{Y_{CR}}{a_p}\right| > \frac{\varepsilon_{SP}}{2}$

otherwise $T_p = 0$ (167)

$$M_{SSi} = K_{SLi} \left[\left(\delta_{FWi} - \frac{Y_{CR}}{a_{Li}}\right) - \frac{\varepsilon_{pi}}{2} \operatorname{sgn}\left(\delta_{FWi} - \frac{Y_{CR}}{a_{Li}}\right)\right]$$

if $\left|\delta_{FWi} - \frac{Y_{CR}}{a_{Li}}\right| > \frac{\varepsilon_{pi}}{2}$

otherwise $M_{SSi} = 0$ (168)

2.22 Longitudinal and Lateral Accelerations

The longitudinal and lateral accelerations of the sprung mass are computed by the following equations:

$$A_x = (\dot{u} - vr + wq)/g \tag{169}$$

$$A_y = (\dot{v} + ru - wp)/g \tag{170}$$

2.23 Dual Tires on Solid Rear Axle

2.23.1 Equations of Motion

$$M_{uR}\,\dot{w} + M_{uR}\,b\,\dot{q} + M_{uR}\,\ddot{\delta}_R = M_{uR}\,(uq - vp + g) \quad \text{(8-H)}$$

$$-2\,(F_{R3} + F_{R4}) + S_3 + S_4$$

where

$$(F_{R3} + F_{R4}) = K_{T3}\,(R_w + Z_{3DE})$$

$$+ K_{T4}\,(R_w + Z_{4DE}) \tag{171}$$

2.23.2 Suspension Forces

$$F_{APRi} = (P_{R0} + P_{R1}\,\zeta_i' + P_{R2}\,\zeta_i'^2)\,(F_{xui} + F_{xu(i+2)}) \qquad (172)$$

$$i = 3,4$$

$$F_{ARRi} = (R_{R0} + R_{R1}\,\zeta_i' + R_{R2}\,\zeta_i'^2)\,(F_{yui} + F_{yu(i+2)}) \qquad (173)$$

$$i = 3,4$$

$$\zeta_i' = \delta_R - (-1)^i \left(\frac{T_{IR} + T_{OR}}{2}\right) \phi_R \qquad (174)$$

$$i = 3,4$$

2.23.3 Wheel Orientation

$$\Psi_3 = K_{RS}\,\phi_R + K_{SR}\,\frac{M_{ZR3}}{2} \qquad (175)$$

$$\Psi_4 = K_{RS}\,\phi_R + K_{SR}\,\frac{M_{ZR4}}{2} \qquad (176)$$

2.23.4 Resultant Forces and Moments

Tire forces:

$$F_{yui} = -F_{iRID}\,\phi + F_{CiID}\,\mathrm{SIN}\,\Psi_i + F_{SiID}\,\mathrm{COS}\,\Psi_i \qquad (177)$$

$$i = 3,4$$

$$F_{yui} = -F_{iROD}\,\phi + F_{CiOD}\,\mathrm{SIN}\,\Psi_{(i-2)} + F_{SiOD}\,\mathrm{COS}\,\Psi_{(i-2)} \qquad (178)$$

$$i = 5,6$$

$$F_{xui} = F_{iRID}\ \theta + F_{CiID} \cos \Psi_i - F_{SiID} \sin \Psi_i \tag{179}$$

$i = 3,4$

$$F_{xui} = F_{iROD}\ \theta + F_{CiOD} \cos \Psi_{(i-2)} - F_{SiOD} \sin \Psi_{(i-2)} \tag{180}$$

$i = 5,6$

Aligning Moments:

$$M_{ZiRID} = (A_{R1}\ F_{iRID} + A_{R2}\ |F_{SiID}|)\ F_{SiID} \tag{181}$$

$i = 3,4$

$$M_{ZiROD} = (A_{R1}\ F_{iROD} + A_{R2}\ |F_{SiOD}|)\ F_{SiOD} \tag{182}$$

$i = 5,6$

$$M_{ZRi} = M_{ZiRID} + M_{Z(i+2)ROD} \tag{183}$$

$i = 3$

$$M_{ZRi} = M_{ZiRID} = M_{Z(i+2)ROD} \tag{184}$$

$i = 4$

Overturning Moments:

$$M_{XiRID} = Q_{R1}\ F_{SiID}\ F_{iRID} \tag{185}$$

$i = 3,4$

$$M_{XiROD} = Q_{R1}\ F_{SiOD}\ F_{iRID} \tag{186}$$

$i = 5,6$

$$M_{XRi} = M_{XiRID} = M_{X(i+2)ROD} \qquad (187)$$

$i = 3$

$$M_{XRi} = M_{XiRID} + M_{X(i+2)ROD} \qquad (188)$$

$i = 4$

Suspension and Tire Moments:

$$\begin{aligned}
\Sigma N_{\psi u} = {} & (F_{yu1} + F_{yu2})\ a \\
& - (F_{yu3} + F_{yu4} + F_{yu5} + F_{yu6})\ b \\
& + (F_{xu2} - F_{xu1}) \frac{T_F}{2} \\
& + (F_{xu4} - F_{xu3}) \frac{T_{IR}}{2} \\
& + (F_{xu6} - F_{xu5}) \frac{T_{OR}}{2} + \sum_{i=1}^{2} M_{ZFi} + \sum_{i=3}^{4} M_{ZRi}
\end{aligned} \qquad (189)$$

$$\begin{aligned}
\Sigma N_{\phi u} = {} & (S_2 - S_1) \frac{T_F}{2} + (S_4 - S_3) \frac{T_{SR}}{2} \\
& - F_{yu1}\ (z_F + \delta_1 + h_1 - H_{FC}) \\
& - F_{yu2}\ (z_F + \delta_2 + h_2 - H_{FC}) \\
& - (F_{yu3} + F_{yu4} + F_{yu5} + F_{yu6})\ (z_R + \delta_R) \\
& + \sum_{i=1}^{2} M_{XFi}
\end{aligned} \qquad (190\text{-H})$$

$$\Sigma \dot{N}_{\theta u} = (S_1 + S_2)\, a - (S_3 + S_4)\, b$$

$$+ F_{xu1}\, (z_F + \delta_1 + h_1) + F_{xu2}\, (z_F + \delta_2 + h_2)$$

$$+ F_{xu3}\, \left(z_R + \delta_R - Z_{3ID} + \frac{T_{IR}}{2}\, \phi_R\right)$$

$$+ F_{xu4}\, \left(z_R + \delta_R - Z_{4ID} - \frac{T_{IR}}{2}\, \phi_R\right)$$

$$+ F_{xu5}\, \left(z_R + \delta_R - Z_{5OD} + \frac{T_{OR}}{2}\, \phi_R\right)$$

$$+ F_{xu6}\, \left(z_R + \delta_R - Z_{6OD} - \frac{T_{OR}}{2}\, \phi_R\right) \tag{191-H}$$

$$\Sigma N_{\phi R} = (S_3 - S_4)\, \frac{T_{SR}}{2} + F_{R3}\, [-2\, (T_{OIR} + Z_{3DE}\, \phi_R)]$$

$$+ F_{R4}\, [2\, (T_{OIR} - Z_{4DE}\, \phi_R)] - F_{yu3}\, \left(-Z_{3ID} + \frac{T_{IR}}{2}\, \phi_R\right)$$

$$- F_{yu4}\, \left(-Z_{4ID} - \frac{T_{IR}}{2}\, \phi_R\right)$$

$$- F_{yu5}\, \left(-Z_{5OD} + \frac{T_{OR}}{2}\, \phi_R\right)$$

$$- F_{yu6}\, \left(-Z_{6OD} - \frac{T_{OR}}{2}\, \phi_R\right)$$

$$+ \sum_{i=3}^{4} M_{XRi} \tag{192}$$

2.23.5 Radial Tire Force and Rolling Radius

$$F_{3RID} = K_{T3} (R_W + Z_{3ID}) \qquad (R_W + Z_{3ID}) > 0$$

$$= 0 \qquad (R_W + Z_{3ID}) \leq 0 \tag{193}$$

$$F_{4RID} = K_{T4} (R_W + Z_{4ID}) \qquad (R_W + Z_{4ID}) > 0$$

$$= 0 \qquad (R_W + Z_{4ID}) \leq 0 \tag{194}$$

$$F_{5ROD} = K_{T3} (R_W + Z_{5OD}) \qquad (R_W + Z_{5OD}) > 0$$

$$= 0 \qquad (R_W + Z_{5OD}) \leq 0 \tag{195}$$

$$F_{6ROD} = K_{T4} (R_W + Z_{6OD}) \qquad (R_W + Z_{6OD}) > 0$$

$$= 0 \qquad (R_W + Z_{6OD}) \leq 0 \tag{196}$$

$$T_{OIR} = \frac{T_{IR} + T_{OR}}{4} \tag{197}$$

$$T_{IOR} = \frac{T_{IR} - T_{OR}}{4} \tag{198}$$

$$Z_{3DE} = Z + b\theta + z_R + \delta_R + T_{OIR} (\phi + \phi_R) \tag{199}$$

$$Z_{4DE} = Z + b\theta + z_R + \delta_R - T_{OIR} (\phi + \phi_R) \tag{200}$$

$$Z_{3ID} = Z_{3DE} + T_{IOR} (\phi + \phi_R) \tag{201}$$

$$Z_{4ID} = Z_{4DE} - T_{IOR} (\phi + \phi_R) \tag{202}$$

$$Z_{5OD} = Z_{3DE} - T_{IOR} (\phi + \phi_R) \tag{203}$$

$$Z_{6OD} = Z_{4DE} + T_{IOR} (\phi + \phi_R) \tag{204}$$

where

$$h_{3(O)} = h_{4(O)} = R_w - \frac{g}{4K_{T3}} [M_{ur} + (\frac{a}{a+b}) M_S] \tag{205}$$

2.23.6 <u>Tire Circumferential Force</u>

$$F_{CiID} = -\mu'_{iID} F_{iRID} \qquad i = 3,4 \tag{206}$$

$$F_{CiOD} = -\mu'_{iOD} F_{iROD} \qquad i = 5,6 \tag{207}$$

2.23.7 <u>Circumferential Coefficient of Friction</u>

$$\begin{aligned} \mu'_{iID} &= m_{1i} S_{iID} && \text{for } S_{iID} \leq SI_i \\ &= m_{2i} S_{iID} + \mu_{Oi} && \text{for } S_{iID} > SI_i \\ & && i = 3,4 \end{aligned} \tag{208}$$

$$\begin{aligned} \mu'_{iOD} &= m_{1(i-2)} S_{iID} && \text{for } S_{iID} \leq SI_{(i-2)} \\ &= m_{2(i-2)} S_{iID} + \mu_{O(i-2)} && \text{for } S_{iID} > SI_{(i-2)} \\ & && i = 5,6 \end{aligned} \tag{209}$$

$$\mu_{yiID} = (B_{1R}\, F_{iRID} + B_{2R}\, C_{vi} + B_{3R}$$

$$+ B_{4R}\, F_{iRID}^{\;2})\ SN_i \qquad (210)$$

$i = 3,4$

$$\mu_{yiOD} = (B_{IR}\, F_{iROD} + B_{2R}\, C_{v(i-2)} + B_{3R}$$

$$+ B_{4R}\, F_{iROD}^{\;2})\ SN_{(i-2)} \qquad (211)$$

$i = 5,6$

2.23.8 Wheel Slip

Analog:

$$\begin{aligned} (SLIP)_i &= 1 && \text{for } \xi_i > 1 \\ &= \xi_i && \text{for } -1 \le \xi_i \le 1 \\ &= -1 && \text{for } \xi_i < -1 \qquad (212) \end{aligned}$$

where

$$\xi_i = 1 + \frac{\omega_i\ Z_{iDE}}{u_{Gi}\ COS\ \Psi_i + v_{Gi}\ SIN\ \Psi_i} \qquad (213)$$

$i = 3,4$

Digital:

$$S_{iID} = 1 \qquad \text{for } \xi_i > 1$$

$$= \xi_i \qquad \text{for } -1 \le \xi_i \le 1$$

$$= -1 \qquad \text{for } \xi_i < -1 \tag{214}$$

$$\xi_i = 1 + \frac{\omega_i \, z_{iID}}{u_{GiID} \, \text{COS} \, \Psi_i + v_{GiID} \, \text{SIN} \, \Psi_i} \tag{215}$$

$i = 3,4$

$$S_{iOD} = 1 \qquad \text{for } \xi_i > 1$$

$$= \xi_i \qquad \text{for } -1 \le \xi_i \le 1$$

$$= -1 \qquad \text{for } \xi_i < -1 \tag{216}$$

$$\xi_i = 1 + \frac{\omega_{(i-2)} \, z_{iOD}}{u_{GiOD} \, \text{COS} \, \Psi_{(i-2)} + v_{GiOD} \, \text{SIN} \, \Psi_{(i-2)}} \tag{217}$$

$i = 5,6$

$$u_{G3ID} = u_{3ID} + \theta w_{3ID} \tag{218}$$

$$u_{G4ID} = u_{4ID} + \theta w_{4ID} \tag{219}$$

$$u_{G5OD} = u_{5OD} + \theta w_{5OD} \tag{220}$$

$$u_{G6OD} = u_{6OD} + \theta w_{6OD} \tag{221}$$

$$v_{G3ID} = v_{3ID} - \phi w_{3ID} \tag{222}$$

$$v_{G4ID} = v_{4ID} - \phi w_{4ID} \tag{223}$$

$$v_{G5OD} = v_{5OD} - \phi w_{5OD} \tag{224}$$

$$v_{G6OD} = v_{6OD} - \phi w_{6OD} \tag{225}$$

$$u_{3ID} = u_3 - T_{IOR}\ r \tag{226}$$

$$u_{4ID} = u_4 + T_{IOR}\ r \tag{227}$$

$$u_{5OD} = u_3 + T_{IOR}\ r \tag{228}$$

$$u_{6OD} = u_4 - T_{IOR}\ r \tag{229}$$

$$v_{3ID} = v - br - z_R p + Z_{3ID}\ (p + \dot{\phi}_R) \tag{230}$$

$$v_{4ID} = v - br - z_R p + Z_{4ID}\ (p + \dot{\phi}_R) \tag{231}$$

$$v_{5OD} = v - br - z_R p + Z_{5OD}\ (p + \dot{\phi}_R) \tag{232}$$

$$v_{6OD} = v - br - z_R p + Z_{6OD}\ (p + \dot{\phi}_R) \tag{233}$$

$$w_{3ID} = w_3 + T_{IOR}\ (p + \dot{\phi}_R) \tag{234}$$

$$w_{4ID} = w_4 - T_{IOR}\ (p + \dot{\phi}_R) \tag{235}$$

$$w_{5OD} = w_3 - T_{IOR}\ (p + \dot{\phi}_R) \tag{236}$$

$$w_{6OD} = w_4 + T_{IOR}\ (p + \dot{\phi}_R) \tag{237}$$

2.23.9 Wheel Rotational Equations

Analog:

$$(I_{WR} + \frac{1}{4} I_{DR} \overline{AR}_R^2)\ \dot{\omega}_3 + (\frac{1}{4} I_{DR} \overline{AR}_R^2)\ \dot{\omega}_4$$

$$= 2(F_{C3}\ Z_{3DE}) + \overline{TQ}_3 \tag{238}$$

$$(I_{WR} + \frac{1}{4} I_{DR} \overline{AR}_R^2)\ \dot{\omega}_4 + (\frac{1}{4} I_{DR} \overline{AR}_R^2)\ \dot{\omega}_3$$

$$= 2(F_{C4}\ Z_{4DE}) + \overline{TQ}_4 \tag{239}$$

$$F_{C3} = -\mu_3'\ F_{R3} \tag{240}$$

$$F_{C4} = -\mu_4'\ F_{R4} \tag{241}$$

2.23.10 Tire Side Force

$$F_{SiID} = F_{iRID}\ \{|\mu_{yiID}\ g(\overline{\beta})_i| - [|\mu_{yiID}\ g(\overline{\beta})_i|$$

$$-\mu_{SR}\ |SIN\ (\beta_i)|\ SN_i]\ F_i\ \}\ SGN\ g(\overline{\beta})_i \tag{242}$$

$$i = 3,4$$

$$F_{SiOD} = F_{iROD}\ \{|\mu_{yiOD}\ g(\overline{\beta})_{(i-2)}| - [|\mu_{yiOD}\ g(\overline{\beta})_{(i-2)}|$$

$$-\mu_{SR}\ |SIN\ (\beta_{i-2})|SN_{(i-2)}]\ F_{i-2}\}\ SGN\ g(\overline{\beta})_{(i-2)} \tag{243}$$

$$i = 5,6$$

2.23.11 Velocities of Tire Contact Points

$$u_3 = u - T_{OIR}\, r + z_R\, q \qquad (244)$$

$$u_4 = u + T_{OIR}\, r + z_R\, q \qquad (245)$$

$$u_5 = u - T_{OIR}\, r + z_R\, q \qquad (246)$$

$$u_6 = u + T_{OIR}\, r + z_R\, q \qquad (247)$$

$$v_3 = v - br - [z_R - Z_{3DE}]\, p + Z_{3DE}\, \dot{\phi}_R \qquad (248)$$

$$v_4 = v - br - [z_R - Z_{4DE}]\, p + Z_{4DE}\, \dot{\phi}_R \qquad (249)$$

$$v_5 = v - br - [z_R - Z_{3DE}]\, p + Z_{3DE}\, \dot{\phi}_R \qquad (250)$$

$$v_6 = v - br - [z_R - Z_{4DE}]\, p + Z_{4DE}\, \dot{\phi}_R \qquad (251)$$

$$w_3 = w + bq + \dot{\delta}_R + (p + \dot{\phi}_R)\, T_{OIR} \qquad (252)$$

$$w_4 = w + bq + \dot{\delta}_R - (p + \dot{\phi}_R)\, T_{OIR} \qquad (253)$$

$$w_5 = w + bq + \dot{\delta}_R + (p + \dot{\phi}_R)\, T_{OIR} \qquad (254)$$

$$w_6 = w + bq + \dot{\delta}_R - (p + \dot{\phi}_R)\, T_{OIR} \qquad (255)$$

Wheel velocities in the ground plane:

$$u_{Gi} = u_i + \theta w_i \tag{256}$$

$$v_{Gi} = v_i - \phi w_i \qquad i = 3,4,5,6 \tag{257}$$

2.23.12 Wheel Camber with Respect to the Road

$$\phi_{CGi} = 0 \qquad i = 3,4,5,6 \tag{258}$$

2.24 Solid Front Axle and Dual Tires on Solid Rear Axle

2.24.1 Resultant Moments

$$\begin{aligned} \Sigma N_{\phi u} = {} & (S_2 - S_1) \frac{T_{SF}}{2} + (S_4 - S_3) \frac{T_{SR}}{2} \\ & -(F_{yu1} + F_{yu2}) (z_F + \delta_F) \\ & -(F_{yu3} + F_{yu4} + F_{yu5} + F_{yu6}) (z_R + \delta_R) \end{aligned} \tag{190-I}$$

$$
\begin{aligned}
\Sigma N_{\theta u} = {} & (S_1 + S_2)\, a - (S_3 + S_4)\, b \\
& + F_{xu1}\left(z_F + \delta_F + \frac{T_F}{2}\phi_F + h_1\right) \\
& + F_{xu2}\left(z_F + \delta_F - \frac{T_F}{2}\phi_F + h_2\right) \\
& + F_{xu3}\left(z_R + \delta_R + \frac{T_{IR}}{2}\phi_R - Z_{3ID}\right) \\
& + F_{xu4}\left(z_R + \delta_R - \frac{T_{IR}}{2}\phi_R - Z_{4ID}\right) \\
& + F_{xu5}\left(z_R + \delta_R + \frac{T_{OR}}{2}\phi_R - Z_{5ID}\right) \\
& + F_{xu6}\left(z_R + \delta_R - \frac{T_{OR}}{2}\phi_R - Z_{6ID}\right)
\end{aligned}
\tag{191-I}
$$

3. NOTATION AND LIST OF SYMBOLS

3.1 Notation

The time derivative of a variable is indicated by a dot over the symbol for the variable, e.g.,

$$\dot{\alpha} = d\alpha/dt, \quad \ddot{\alpha} = d^2\alpha/dt^2$$

Special symbols for mathematical operations:

$$|\alpha| = \text{absolute value of } \alpha$$

$$\text{sgn } \alpha = \text{algebraic sign of } \alpha$$

The following subscript notation is used:

i = wheel identification number,

1 = right front, 2 = left front, 3 = right rear
4 = left rear, 5 = right rear outside,
6 = left rear outside

j = identification of vehicle end,

j = F, R for the front and the rear, respectively

s = sprung mass

u = unsprung mass

F = front, or front axle

R = rear, or rear axle

The technical dimension system is employed with the fundamental units of lb (force), in. (length), and sec (time).

3.2 List of Symbols

3.2.1 Variables

A_x = longitudinal acceleration of the sprung mass, gees.

A_Y = lateral acceleration of the sprung mass, gees.

C_L, C_M, C_N = aerodynamic moment coefficients, given as tabular functions of τ for $\alpha = 0$.

C_{vi} = resultant velocity of the contact point of wheel i in the ground plane, in./sec.

C_X, C_Y, C_Z = aerodynamic force coefficients, given as tabular functions of τ for $\alpha = 0$.

d_{CG} = horizontal distance between aerodynamic center and sprung mass c.g., in.

F_{1Fi}, F_{1Ri} = coulomb damping force in front and rear suspensions, respectively, lb.

F_{2Fi}, F_{2Ri} = suspension force produced by deflection of springs and bump stops in front and rear suspensions, respectively, lb.

F_{3Fi}, F_{3Ri} = viscous damping force in front and rear suspensions, respectively, lb.

F_{4Fi}, F_{4Ri} = suspension force produced by auxiliary roll stiffness in front and rear suspensions, respectively, lb.

F_{APFi}, F_{APRI} = antipitch force in front and rear suspensions, respectively, lb.

F_{ARFi}, F_{ARRi} = antiroll force in front and rear suspensions, respectively, lb.

F_{BSi} = suspension force component which is the difference between analog value and actual spring characteristic at wheel i, lb.

F_{Ci} = tire circumferential force at wheel i, lb.

F_{CiID}, F_{CiOD} = dual tire circumferential force at rear inside and outside wheel, respectively, lb.

FF, FR = front and rear brake torque curves which are input as functions of brake line pressure, lb in.

$F_i[(SLIP)_i]$ = nondimensional tire side-force shaping function versus longitudinal slip at wheel i.

F_{iRID}, F_{iROD} = dual tire radial force at rear inside and outside wheel, respectively, lb.

F_{Ri} = tire radial force at wheel i, lb.

F_{Si} = tire side force at wheel i, lb.

F_{SiID}, F_{SiOD} = dual tire side force at rear inside and outside wheel, respectively, lb.

F_{SWF}, F_{SWR} = front and rear static component of the sprung mass, lb.

F_{xui}, F_{yui}, F_{zui} = tire force components at wheel i along the sprung mass x-, y-, z-axes, respectively, lb.

$\Sigma F_{xs}, \Sigma F_{ys}, \Sigma F_{zs}$ = components of the resultant of aerodynamic forces that act directly on the sprung mass, along the sprung mass x-, y-, z-axes, respectively, lb.

$\Sigma F_{xu}, \Sigma F_{yu}, \Sigma F_{zu}$ = components of the resultant of forces that act on the unsprung masses, along the sprung mass x-, y-, z-axes, respectively, lb.

$g(\overline{\beta}_i)$ = nondimensional tire side force shaping function for combined slip angle and camber angle at wheel i.

h_i = rolling radius of wheel i, in.

m_{1i}, m_{2i} = slope of straight-line segments approximating circumferential friction coefficient at wheel i.

M_{SSi} = torque applied to front wheel i by the steering system connecting rod, lb in.

M_{Ti} = moment acting at front wheel i about the kingpin axis due to tire-road contact forces, lb in.

M_{XFi}, M_{XRi} = tire overturning moment at wheel i, front and rear wheels, respectively, lb in.

M_{XiRID}, M_{XiROD} = dual tire overturning moment at rear inside and outside wheel, respectively, lb in.

M_{ZFi}, M_{ZRi} = tire aligning moment at wheel i, front and rear wheels, respectively, lb in.

M_{ZiRID}, M_{ZiROD} = dual tire aligning moment at rear inside and outside wheel, respectively, lb in.

$\Sigma N_{\phi F}$ = rolling moment acting on the front axle, lb in.

$\Sigma N_{\phi R}$ = rolling moment acting on the rear axle, lb in.

$\Sigma N_{\phi s}$, $\Sigma N_{\theta s}$, $\Sigma N_{\psi s}$ = components of the resultant moment of aerodynamic forces that act directly on the sprung mass, about the sprung mass x-, y-, z-axes, respectively, lb in.

$\Sigma N_{\phi u}$, $\Sigma N_{\theta u}$, $\Sigma N_{\psi u}$ = components of the resultant moment of forces that act on the unsprung masses, about the sprung mass x-, y-, z-axes, respectively, lb in.

p, q, r = scalar components of angular velocity of the sprung mass, taken about the sprung mass x-, y-, z-axes, respectively, rad/sec.

$\bar{p}$, $\bar{q}$, $\bar{r}$ = dimensionless components of angular velocity of vehicle relative to wind in vehicle-fixed axes.

P_{FL} = brake line pressure, lb/in.^{2}

q_a = dynamic pressure, lb/in.^{2}

S_i = total suspension force at wheel i, effective at the wheel for independent suspensions and at the spring location for the solid front/rear axle, lb.

$(SLIP)_i$ = longitudinal slip ratio at wheel i.

S_{iID}, S_{iOD} = longitudinal slip ratio at dual rear inside and outside wheel, respectively.

T_p = Pitman torque at the steering gear box, lb in.

$\overline{TQ}_{Bi}$ = brake torque at wheel i, lb in.

$\overline{TQ}_{D}$ = drive torque, lb in.

$\overline{TQ}_{DMAX}$ = maximum drive torque, lb in.

u, v, w = scalar components of linear velocity of the sprung mass, taken along the sprung mass x-, y-, z-axes, respectively, in./sec.

u_i, v_i, w_i = velocity components of the contact point of wheel i along the vehicle-fixed axes, in./sec.

u_{iID}, u_{iOD} = forward velocity component of the contact point of dual rear inside and outside wheel, respectively, along the vehicle-fixed axes, in./sec.

u_r, v_r, w_r = components of vehicle velocity relative to wind in vehicle-fixed axes, in./sec.

u_{Gi} = forward velocity of the contact point of wheel i in the ground plane, in./sec.

u_{GiID}, u_{GiOD} = forward velocity of the contact point of dual rear inside and outside wheel, respectively, in the ground plane, in./sec.

V_{CW} = magnitude of vehicle velocity relative to wind, in./sec.

v_{Gi} = lateral velocity of the contact point of wheel i in the ground plane, in./sec.

v_{GiID}, v_{GiOD} = lateral velocity of the contact point of dual rear inside and outside wheel, respectively, in the ground plane, in./sec.

v_{iID}, v_{iOD} = lateral velocity component of the contact point of dual rear inside and outside wheel, respectively, along the vehicle-fixed axes, in./sec.

w_{iID}, w_{iOD} = downward velocity component of the contact point of dual rear inside and outside wheel, respectively, along the vehicle-fixed axes, in./sec.

x, y, z = coördinates of a point relative to the vehicle-fixed coordinate axis system, in.

X, Y, Z = coordinates of the center of gravity of the sprung mass relative to the space-fixed coordinate axis system, in.

y_{CR} = linear displacement of the steering system connecting rod, in.

z_i = coordinate of individual wheel center above the road surface, in.

z_{iID}, z_{iOD} = inertial position of the rear dual inside and outside wheel center, respectively, in.

z_{MXi} = wheel contact/lift-off indicator.

z_{si} = input function to wheel center i which represents elevation change in reference surface (initially equal to zero), in.

Z_{3DE}, Z_{4DE} = inertial position of a single equivalent wheel center replacing the right and left pair of rear dual wheel centers respectively, in.

α = aerodynamic angle of attack, rad.

β = vehicle body angle of sideslip, rad.

β_i = slip angle at wheel i, rad.

β_i' = "equivalent" slip angle produced by camber effects at wheel i, rad.

$\overline{\beta}_i$ = nondimensional slip angle variable for wheel i

δ_i = suspension deflection relative to the vehicle from the position of static equilibrium, measured at the center of wheel i, in.

δ_{FWi} = angular displacement of front wheel i produced by the steering system, rad.

δ_F = suspension deflection relative to the vehicle from the position of static equilibrium at the center of the solid front axle, in.

δ_R = suspension deflection relative to the vehicle from the position of static equilibrium at the center of the solid rear axle, in.

δ_{Si} = suspension deflection relative to the vehicle, measured at the center of wheel i from the position of static equilibrium at curb (no-load) condition, in.

δ_{SW} = steering wheel displacement, rad.

ζ_i = suspension deflection relative to the vehicle from the position of static equilibrium, measured at the spring location i, in.

ζ_{Si} = suspension deflection relative to the vehicle, measured at the spring location from the position of static equilibrium at curb (no-load) condition, in.

ζ_i' = deflection of the center of wheel i (solid front/rear axle) relative to the vehicle from the position of static equilibrium, in.

θ_{Si} = caster angle of front wheel i relative to the vehicle-fixed coordinate axis system, positive for rearward inclination of the steering axis in the upward direction, rad.

μ_{iID}', μ_{iOD}' = circumferential friction coefficient at dual rear inside and outside wheel, respectively.

μ_{yiID}, μ_{yiOD} = lateral friction coefficient at dual rear inside and outside wheel, respectively.

μ_{0i}, μ_{1i} = circumferential friction coefficient at braking slip equal to zero and one, respectively.

μ_{PF}, μ_{PR} = peak braking friction coefficient, front and rear wheels, respectively.

μ_{yi} = lateral friction coefficient at wheel i

μ_i' = circumferential friction coefficient at wheel i.

τ = aerodynamic angle of side slip, rad.

ϕ, θ, ψ = Euler angular coordinates (roll, pitch, and yaw angles) of the sprung mass relative to the space-fixed coordinate axis system, rad.

ϕ_i = camber angle of wheel i relative to the vehicle-fixed coordinate axis system, positive when clockwise as viewed from the rear, rad.

ϕ_{CGi} = camber angle of wheel i relative to the ground plane, rad.

ϕ_F = angular displacement of the front axle relative to the vehicle about a line parallel to the x-axis through the front axle c.g., positive when counterclockwise as viewed from the front, rad.

ϕ_R = angular displacement of the rear axle relative to the vehicle about a line parallel to the x-axis through the rear axle c.g., positive when clockwise as viewed from the rear, rad.

ψ_i = steer angle of wheel i relative to the vehicle-fixed coordinate axis system, positive for clockwise steer as viewed from above vehicle, rad.

ω_i = rotational velocity of wheel i, rad/sec.

3.2.2 Parameters

a = distance in the x-direction between the center of gravity of the sprung mass and the centerline of the front wheels, in.

a_{Li} = length of steering linkage arm at front wheel i, in.

a_p = length of Pitman arm, in.

A_{0F}, A_{1F}, A_{2F} = coefficients of second degree curves fitted to small-angle cornering stiffness, front wheels.

A_{3F}, A_{4F} = coefficients of second degree curves fitted to small-angle camber stiffness, front wheels.

A_{0R}, A_{1R}, A_{2R} = coefficients of second degree curves fitted to small-angle cornering stiffness, rear wheels.

A_{3R}, A_{4R} = coefficients of second degree curves fitted to small-angle camber stiffness, rear wheels.

A_{F1}, A_{F2}, A_{F3} = coefficients of functions fitted to tire aligning torque, front wheels.

A_{R1}, A_{R2}, A_{R3} = coefficients of functions fitted to tire aligning torque, rear wheels.

$\overline{AR}_F$ = drive axle ratio for the front, i.e., propeller shaft speed to wheel speed.

$\overline{AR}_R$ = drive axle ratio for the rear, i.e., propeller shaft speed to wheel speed.

$A\Omega_{TF}$, $A\Omega_{TR}$ = proportionality factor defining limits of small-angle cornering and camber stiffness variation with tire loading, front and rear wheels, respectively.

b = distance in the x-direction between the c.g. of the sprung mass and the centerline of the rear wheels, in.

B_{1F}, B_{2F}, B_{3F}, B_{4F} = coefficients of curves fitted to lateral friction coefficient, front wheels.

B_{1R}, B_{2R}, B_{3R}, B_{4R} = coefficients of curves fitted to lateral friction coefficients, rear wheels.

C_{iF}, C_{iR} = coefficients of 5th degree polynomials (i = 0 to 5) fitted to wheel camber angle versus suspension deflection, front and rear wheels, respectively.

C_{CR} = viscous damping in steering gear, effective at the steering system connecting rod, lb sec/in.

C_{FCR} = coulomb friction in steering gear, effective at the steering system connecting rod, lb.

C_{Fk} = slope of straight-line segments (k = 1 to 4) fitted to the shock absorber force characteristics for a single wheel, effective at the spring location for the solid front axle and at the front wheel for independent front suspension, lb sec/in.

C_{Rk} = slope of straight-line segments (k = 1 to 4) fitted to the shock absorber force characteristics for a single wheel, effective at the spring location for the solid rear axle and at the rear wheel for independent rear suspensions, lb sec/in.

C'_{Fi}, C'_{Ri} = coulomb damping for a single wheel, effective at the wheel for independent suspensions and at the spring location for the solid front/rear axle, front and rear wheels, respectively.

C_{y_p}, C_{y_r}, C_{z_α}, C_{z_q}, C_{ℓ_p},

C_{ℓ_r}, C_{m_α}, C_{m_q}, C_{n_p}, C_{n_r} = aerodynamic stability derivatives.

D_{iF}, D_{iR} = coefficients of 5th degree polynomials (i = 0 to 5) fitted to wheel toe angle versus suspension deflection, front and rear wheels, respectively.

E_{iF} = coefficients of 5th degree polynomials (i = 0 to 5) fitted to front wheel caster angle versus suspension deflection.

g = acceleration due to gravity
= 386.4 in./sec.^{2}

H_i = viscous damping derivative at front wheel i, lb in. sec/rad.

H_{FC} = distance between the ground and the roll center of the independent front suspension, in.

H_{RC} = distance between the ground and the roll center of the independent rear suspension, in.

I_{DF} = drive-line moment of inertia for front wheel drive, lb in. sec.^{2}

I_{DR} = drive-line moment of inertia for rear wheel drive, lb. in. sec.^{2}

I_F = moment of inertia of solid front axle about a line through its center of gravity and parallel to the x-axis, lb in. sec.^{2}

I_{FW} = moment of inertia of individual front wheel about the king-pin axis, lb in. sec.^{2}

I_R = moment of inertia of solid rear axle about a line through its center of gravity and parallel to the x-axis, lb in. sec.^{2}

I_{WF}, I_{WR} = moment of inertia of individual wheel about its spin axis, front and rear wheels, respectively, lb in. sec.^{2}

I_x, I_y, I_z = moment of inertia of sprung mass about the x-, y-, z-axes, respectively, lb in. sec.^{2}

I_{xz} = product of inertia of sprung mass with respect to the x- and z-axes, lb in. sec.^{2}

I'_x, I'_y, I'_z = moment of inertia of unsprung mass, lb in. sec.^{2}

I'_{xz} = product of inertia of unsprung mass, lb in. sec.^{2}

K_{CF}, K_{CR} = lateral force compliance camber coefficient, front and rear wheels, respectively, rad/lb.

K_{Fi} = suspension load-deflection rate for a single wheel in the quasi-linear range about the position of static equilibrium, effective at the spring location for the solid front axle and at the front wheel for independent front suspensions, lb/in.

K_{Ri} = suspension load-deflection rate for a single wheel in the quasi-linear range about the position of static equilibrium, effective at the spring location for the solid rear axle and at the rear wheel for independent rear suspensions, lb/in.

K_{FS} = roll steer coefficient of the solid front axle, positive for roll understeer, rad/rad.

K_{RS} = roll steer coefficient of the solid rear axle, positive for roll understeer, rad/rad.

K_{SC} = flexibility in steering column and steering gear box, lb in./rad.

K_{SLi} = flexibility in steering linkage at front wheel i, lb in./rad.

K_{SR} = aligning torque compliance steer coefficient at the rear wheels, rad/(lb in.)

K_{Ti} = tire load-deflection rate in the quasi-linear range for a single tire at wheel i, lb/in.

K_{TQ} = gain in drive torque, lb sec.

ℓ = wheelbase length of vehicle, in.

ℓ_v = characteristic vehicle length upon which aerodynamic moment coefficients are referenced, in.

M_{CR} = effective mass of the steering system connecting rod, lb sec^2/in.

M_S = total sprung mass, lb sec^2/in.

M_{uF} = total front unsprung mass, lb sec^2/in.

M_{uR} = total rear unsprung mass, lb sec^2/in.

ΣM = total vehicle mass, lb sec^2/in.

N_G = gear ratio of the steering gear box.

O_{F0}, O_{F1}, O_{F2}, O_{F3} = coefficients of functions fitted to tire overturning moment, front wheels.

O_{R0}, O_{R1}, O_{R2}, O_{R3} = coefficients of functions fitted to tire overturning moment, rear wheels.

P_{BF1}, P_{BF2} = coefficients of curves fitted to peak braking friction coefficient, front wheels.

P_{BR1}, P_{BR2} = coefficients of curves fitted to peak braking friction coefficient, rear wheels.

P_{F0}, P_{F1}, P_{F2} = coefficients of curves fitted to antipitch coefficient, front wheels.

P_{R0}, P_{R1}, P_{R2} = coefficients of curves fitted to antipitch coefficient, rear wheels.

$\overline{PT}$ = front wheel caster offset, in.

R_F, R_R = auxiliary roll stiffness at front and rear suspensions, respectively, lb in./rad.

R_{F0}, R_{F1}, R_{F2} = coefficients of curves fitted to antiroll coefficients, front wheels.

R_{R0}, R_{R1}, R_{R2} = coefficients of curves fitted to antiroll coefficients, rear wheels

R_W = undeflected wheel radius, in.

S_f = projected frontal area of vehicle, in.^{2}

S_{Ii} = longitudinal slip at wheel i at which peak braking friction occurs.

$(SN)_{S0}$ = skid number of simulated surface.

$(SN)_T$ = skid number of surface on which tire data were obtained.

SN_i = skid number ratio of simulated surface to tire data surface.

T_F, T_R = wheel tread width at the front and rear, respectively, in.

T_{IR} = distance between the centers of inside tires in the y-direction for solid rear axle with dual tires, in.

T_{OR} = distance between the centers of outside tires in the y-direction for solid rear axle with dual tires, in.

T_{SF} = distance in the y-direction between the spring centers for solid front axle, in.

T_{SR} = distance in the y-direction between the spring centers for the solid rear axle, in.

V_c = desired constant vehicle velocity, in/sec.

v_{yw} = velocity of cross wind in space-fixed axes, measured at sprung mass c.g., in./sec.

y_{SAi} = distance between the kingpin axis and wheel centerline, measured along the wheel spin axis at front wheel i, in.

z_{BIAS} = bias constant to vertically shift the vehicle c.g. position, in.

z_F = static distance in the z-direction between the c.g. of the sprung mass and c.g. of the front unsprung masses, in.

z_R = static distance in the z-direction between the c.g. of the sprung mass and c.g. of the rear unsprung masses, in.

δ_{FIN}, δ_{RIN} = static displacement of the independent front/rear suspension from the position of static equilibrium due to loading condition, in.

$\dot{\delta}_{FC}$, $\dot{\delta}_{FE}$, $\dot{\delta}_{RC}$, $\dot{\delta}_{RE}$ = abscissa of the break points in the shock absorber force characteristic (independent front/rear suspension), compression and extension, respectively, in./sec.

ΔC_X = increment in axial force coefficient, given as tabular function of α.

$\Delta\phi_i$ = magnitude of camber play at front wheel i, rad.

$\Delta\theta_i$ = static caster angle bias at front wheel i, rad.

$\Delta\psi_i$ = static toe angle bias at front wheel i, rad.

ε_{pi} = free play in steer of front wheel i, rad.

ε_{sp} = free play in steering gear box, rad.

ζ_{FIN}, ζ_{RIN} = static displacement of the front/rear suspension (solid front/rear axle) from the position of static equilibrium due to loading condition, in.

$\dot{\zeta}_{FC}$, $\dot{\zeta}_{FE}$, $\dot{\zeta}_{RC}$, $\dot{\zeta}_{RE}$ = abscissa of the break points in the shock absorber force characteristic, (solid front/rear axle) compression and extension, respectively, in./sec.

λ_{Bi} = brake torque multiplier at wheel i.

λ_D = drive torque distribution factor.

μ_{SF}, μ_{SR} = coefficient of sliding friction, front and rear wheels, respectively.

ρ_a = air density, lb sec^2/in.^{4}

ϕ_{SAi} = kingpin inclination angle at front wheel i, rad.

ω_{xw}, ω_{zw} = angular velocity of wind in space-fixed axes, rad/sec.

APPENDIX B

HYBRID COMPUTER VEHICLE HANDLING SIMULATION

IMPLEMENTATION DOCUMENTATION

1. PRESENTED HERE IS THE COMPUTER LISTING OF THE DSL/91 DIGITAL STATIC CHECK PROGRAM

```
*
*SUSPENSION FORCE EQUATIONS
*
      F1F1  = SIGN(1.,ZET1DT)*CFP
      F1F2 = SIGN(1.,ZET2DT)*CFP
      F1R3 = SIGN(1.,ZET3DT)*CRP
      F1R4 = SIGN(1.,ZET4DT)*CRP
* ANTI EQUATIONS TO BE INCLUDED IN DSL LATER
*     ANTI1 = AP1+AR1-FBS1
*     ANTI2 = AP2+AR2-FBS2
*     ANTI3 = AP3+AR3-FBS3
*     ANTI4 = AP4+AR4-FBS4
* TEMPORARY ANTI VALUES
      ANTI1 = 450.
      ANTI2 = 300.
      ANTI3 = 350
      ANTI4 = 500.
*
*
      AUXRL1 = (DEL2-DEL1)*RF/TF/TF
       AUXRL2 = (DEL1-DEL2)*RF/TF/TF
*
*RADIAL TIRE FORCE AND ROLLING RADIUS EQUATIONS
*
      Z1P   = RW+ZF+ZO-A*THEO+TF*0.5*PHIO
      Z2P   = RW+ZF+ZO-A*THEO-TF*0.5*PHIO
      Z3P   = ZO+B*THEO+TR*0.5*PHIO+ZR+RW
      Z4P   =ZO+B*THEO-TR*0.5*PHIO+ZR+RW
      FR1    = 0.
      IF((RW+Z1).GT.0.) FR1=AKT1*(RW+Z1)
      FR2    = 0.
      IF((RW+Z2).GT.0.) FR2=AKT2*(RW+Z2)
      FR3    = 0.
      IF((RW+Z3).GT.0.) FR3=AKT3*(RW+Z3)
      FR4    = 0.
      IF((RW+Z4).GT.0.) FR4=AKT4*(RW+Z4)
      FXU1   = FR1*(THEO-U1P*COS(PSI1)-F1*AMU1*SIN(PSI1)*GB1)
      FXU2   = FR2*(THEO-U2P*COS(PSI2)-F2*AMU2*SIN(PSI2)*GB2)
      FXU3   = FR3*(THEO-U3P*COS(PSI3)-F3*AMU3*SIN(PSI3)*GB3)
      FXU4   = FR4*(THEO-U4P*COS(PSI4)-F4*AMU4*SIN(PSI4)*GB4)
      FYU1   = FR1*(-PHIO-U1P*SIN(PSI1)+F1*AMU1*COS(PSI1)*GB1)
      FYU2   = FR2*(-PHIO-U2P*SIN(PSI2)+F2*AMU2*COS(PSI2)*GB2)
      FYU3   = FR3*(-PHIO-U3P*SIN(PSI3)+F3*AMU3*COS(PSI3)*GB3)
      FYU4   = FR4*(-PHIO-U4P*SIN(PSI4)+F4*AMU4*COS(PSI4)*GB4)
      NPHIF =-FR1*(TF*.5+Z1*DEL2)+FR2*(TF*.5-Z2*DEL2)-FYU1*  ...
             (TF*.5*DEL2-Z1)-FYU2*(-TF*.5*DEL2-Z2)+(S1-S2)*TSF*.5
      NPHIR  = -FR3*(TR*0.5+Z3*DEL4)+FR4*(TR*0.5-Z4*DEL4)-FYU3*...
                 (TR*0.5*DEL4-Z3)-FYU4*(-TR*0.5*DEL4-Z4)+(S3-S4)*TS*0.5
*
*
*STEERING SYSTEM EQUATIONS
*ESP,EP1,EP2 DENOTE LIMITER SETTINGS
      TP     = ANG*AKSC*(DELSWO-ANG*YCR/AP-ESP/2.)
      AMSS1  = AKSL1*((DFW1-YCR/AA1)-EP1/2.)
      AMSS2  = AKSL2*((DFW2-YCR/AA2)-EP2/2.)
*
      DFW1DD = (-AH1*DFW1DT+MT1-AMSS1)/AIFW-RDTO
      DFW2DD = (-AH2*DFW2DT+MT2-AMSS2)/AIFW-RDTO
      YCRDD  = (1./AMCR)*(-CFCR - CCR*YCRDT + TP/AP + AMSS1/AA1 +  ...
               AMSS2/AA2)
```

```
*          ********** LISTING OF DSL/91 DIGITAL PROGRAM **********
TITLE ### PROB:52 VEHICLE SIMULATION ###
INCON  DFW2DT=37.    ,DFW2  =0.15  ,YCRDT =80.    ,YCR   =2.55
INCON  RPS1  =43.06  ,RPS2  =43.06 ,RPS3  =43.057,XPS2DT=10000.
INCON  RPS4  =43.057,XPS4DT=10000.,DFW1DT=30.    ,DFW1  =0.35
INCON  PSI1  =.2140  ,PSI2  =.2040 ,PSI3  =.01667,PSI4  =-.0150
INCON  Z0    =-23.4  ,THE0  =.00209,PHI0  =.00300,RDT0  =-500.0
INCON  U01   =.120   ,U02   =1.01  ,U03   =.900  ,U04   =1.250
INCON  U11   =-.6133,U12   =1.11  ,U13   =1.621 ,U14   =1.700
INCON  AM11  =5.25   ,AM12  =-7.40 ,AM13  =-7.50 ,AM14  =-8.30
INCON  TQFBR =8000.  ,TQRBR =7100. ,MT1   =-164.3,MT2   =164.3
INCON  PDT0  =-.12   ,QDT0  =.0900 ,U0    =704.  ,V0    =.1300
INCON  W0    =.0050  ,P0    =.0200 ,Q0    =-.0370,R0    =.0110
INCON  F1    =.9     ,F2    =.8    ,F3    =-.3   ,F4    =.6
INCON  GB1   =.2     ,GB2   =.4    ,GB3   =.5    ,GB4   =.85
PARAM  AMS   =5.162  ,AMUF  =0.359 ,AMUR  =0.574 ,TS    = 35.86
PARAM  AIR   =800.   ,RF    =81E03 ,TF    =54.3  ,RR    =50E03
PARAM  RW    =12.85  ,AIFW  =5.815 ,AH1    =200. ,AH2   =200.
PARAM  AKT1  =812.   ,AKT2  =812.  ,AKT3  =1192. ,AKT4  =1192.
PARAM  AMCR  =0.08   ,CFCR  =200.  ,CCR   =11.   ,AP    =6.06
PARAM  AA1   =5.53   ,AA2   =5.53  ,ANG   =17.5  ,AKSC  =610.
PARAM  ESP   =-.6    ,AKSL1 =1.17E5,AKSL2 =1.17E5,EP1   =-.0200
PARAM  EP2   =-.01   ,AIWF  =7.3777,AID   =0.3   ,ARBR  =4.125
PARAM  AIWR  =7.3777,CFP   =25.   ,CRP   =45.   ,TR    =53.3
PARAM  AKF1  =150.   ,AKF2  =150.  ,AKR3  =200.  ,AKR4  =200.
PARAM  A     =56.3   ,B     =39.0  ,G     =386.4 ,ZF    =10.8
PARAM  ZR    =10.6   ,AMU1  =.1795 ,AMU2  =.1795 ,AMU3  =.2870
PARAM  HRC   =4.70   ,CRRC  =0.0110,TANP  =0.0   ,DELSWO=1.425
PARAM  LB1   =1.65   ,LB2   =1.65  ,LB3   =1.0   ,LB4   =1.0
PARAM  AIDF  = .7    ,ARFBR = 2.7  ,AIF   = 498. ,TSF   = 32.25
PARAM  AMU4  =.2870  ,FOTM  = 250. ,ROTM  = 400. ,HFC   =7.20
PARAM SCALE = 1000. ,RWSF  =20.
*
*
PARAM  AXLE= 0
PARAM  AXLE  =1
PARAM  IDRSW= 0
***COMMENTS***
*          SYMBOLS PHIF AND PHIR ARE NOT USED IN THIS DSL APPLICATION
*       DEL4 AND DEL2 SYMBOLS ARE RETAINED FOR BOTH
*       INDEPENDENT AND SOLID AXLE CONDITIONS.
*       POTS AND AMPLIFIERS ARE QUSASI-ORDERED AT COMPUTATION
*          AND FULLY ORDERED POST-COMPUTATION
*       IDULTR = 0/SINGLE WHEEL ON REAR
*       IDULTR = 1/DUAL WHEELS ON REAR
*       IDRSW = 0/FREE ROLLING FRONT WHEELS
*       IDRSW = 1/POWERED FRONT WHEELS
*       REAR WHEELS ALWAYS POWERED
*
* 231'R SCALED FOR BETA TIMES REAL TIME
* DIGITAL BETA SYMBOL IS ANALOG 1/BETA
*
PARAM  BETA  =0.25
*
CONTRL TSTART=0.0,FINTIM=.002,DELT=.001
DYNAMIC
*
*
*SYSTEM EQUATIONS
```

```
*                                                                       MAIN1950
*WHEEL ROTATIONAL EQUATIONS                                             MAIN1960
*                                                                       MAIN1970
      SFSF  = 1000./10000.                                              MAIN1980
*                                                                       MAIN1990
* CIRCUMFERENTIAL FRICTION COEFFICIENT                                  MAIN2000
*                                                                       MAIN2010
      U1      = U0-TF*0.5*RO+ZF*QO                                      MAIN2020
      U2      = U0+TF*0.5*RO+ZF*QO                                      MAIN2030
      U3      = U0-TR*0.5*RO+ZR*QO                                      MAIN2040
      U4      = U0+TR*0.5*RO+ZR*QO                                      MAIN2050
*                                                                       MAIN 400
*SYSTEM EQUATIONS                                                       MAIN 720
*                                                                       MAIN 730
*   AXLE=0/SOLID FRONT,SOLID REAR
*   AXLE=1/INDEPENDENT FRONT,SOLID REAR
*  AXLE=2/INDEPENDENT FRONT,INDEPENDENT REAR
      IF(AXLE-1) 100,200,300
*                                                                       MAIN1320
*                                                                       MAIN2010
100   CONTINUE
*    SOLID FRONT
      DEL1  = .5
      DEL1DT= 5.
      DEL1DD= SMP/AMS+G+(S1+S2-FR1-FR2)/AMUF+A*QDTO
      DEL2  = .015
      DEL2DT= .95
      DEL2DD=-PDTO+(NPHIF-(FYU1+FYU2)*HFC-TSF*.5+FOTM)/AIF
*
* ZET NOT DERIVED FROM INTEGRATION OF ZETDT                             MAIN1010
      ZET1  = TSF/2.*DEL2+DEL1
      ZET2  =-TSF/2.*DEL2+DEL1
      ZET1DT= TSF/2.*DEL2DT+DEL1DT
      ZET2DT=-TSF/2.*DEL2DT+DEL1DT
      F2F1  =AKF1*ZET1
      F2F2  = AKF2*ZET2
      F3F1  = 201.5
      F3F2  =-041.1
      F4F1  =-RF*DEL2/TSF
      F4F2  = RF*DEL2/TSF
      S1P   = -F1F1-F2F1-F3F1-RF*DEL2/TSF +ANTI1
      S2P   =-F1F2-F2F2-F3F2+RF*DEL2/TSF+ANTI2
      Z1    =Z1P+DEL1+TF*.5*DEL2-RW
      Z2    = Z2P+DEL1-TF*.5*DEL2-RW
      V1    = VO+A*RO-ZF*PO+Z1*DEL2DT
      V2    = VO+A*RO-ZF*PO+Z2*PO+Z2*DEL2DT
      W1    = WO-A*QO+DEL1DT+(DEL2DT+PO)*TF/2.
      W2    = WO-A*QO+DEL1DT-(DEL2DT+PO)*TF/2.
      A005A =-DEL2DT
      A007A = 4.*DEL2
      A014A =DEL2DT
      D005D =DEL2DD/10.*BETA
      D007D =-DEL2DT/2.5*BETA
*                                                                       MAIN1790
*                                                                       MAIN1770
200   CONTINUE
*    SOLID REAR
      DEL3   = 0.8                                                      MAIN 670
      DEL3DT = 20.                                                      MAIN 680
      DEL3DD= SMP/AMS+G+(S3+S4-FR3-FR4)/AMUR-B*QDTO                     MAIN1750
```

```
      DEL4   = 0.01895                                                  MAIN 650
      DEL4DT= .55
      DEL4DD=-PDTO+(NPHIR-(FYU3+FYU4)*HRC-ROTM-TS*.5)/AIR
*                                                                       MAIN1000
* ZET NOT DERIVED FROM INTEGRATION OF ZETDT
      ZET3   = (TS/2.)*DEL4 + DEL3
      ZET4   = -(TS/2.)*DEL4 + DEL3                                     MAIN1080
      ZET3DT = (TS/2.)*DEL4DT+ DEL3DT
      ZET4DT = -(TS/2.)*DEL4DT+ DEL3DT
      F2R3  = AKR3*ZET3
      F2R4  = AKR4*ZET4
      F3R4=195.9
      F3R3=345.6
      S3P   =-F3R3-F2R3-F1R3-(RR/TS)*DEL4+ANTI3
      S4P   =-F3R4-F2R4-F1R4+(RR/TS)*DEL4+ANTI4
      Z3= Z3P+DEL3+TR*0.5*DEL4-RW
      Z4    = Z4P+DEL3-TR*.5*DEL4-RW
*                                                                       MAIN1970
      V3= VO-B*RO-ZR*PO+Z3*PO+Z3*DEL4DT
      V4= VO-B*RO-ZR*PO-Z4*PO+Z4*DEL4DT
      W3=WO-B*QO+DEL3DT+(DEL4DT+PO)*TR*.5
      W4=WO+B*QO+DEL3DT-(DEL4DT+PO)*TR*.5
      A015A =-DEL4DT
      A017A = 4.*DEL4
      D017D =-DEL4DT/2.5*BETA
      D015D = DEL4DD/10.*BETA
      IF (AXLE.EQ.0) GOTO 400
*                                                                       MAIN1990
*                                                                       MAIN 810
300   CONTINUE
*    INDEPENDENT FRONT
      DEL1  = .383
      DEL1DT= 10.
      DEL1DD = SMP/AMS-TF*0.5*PDTO+A*QDTO+2./AMUF*(-FR1+S1-FYU1*...     MAIN1660
              TAN(2.*HFC/TF))+G                                         MAIN1670
      DEL2  = 1.866
      DEL2DT=15.
      DEL2DD = SMP/AMS+TF*0.5*PDTO+A*QDTO+2./AMUF*(-FR2+S2+FYU2*...     MAIN1680
             TAN(2.*HFC/TF))+G                                          MAIN1690
*
*
* ZET NOT DERIVED FROM INTEGRATION OF ZETDT
      ZET1  = DEL1
      ZET1DT= DEL1DT                                                    MAIN1020
      ZET2  = DEL2
      ZET2DT= DEL2DT                                                    MAIN1030
      F2F1  = AKF1*ZET1
      F2F2  = AKF2*ZET2
      F3F1  = 144.0
      F3F2  = 172.3                                                     MAIN 770
      S1P   = AUXRL1-F3F1-F2F1-F1F1+ANTI1                               MAIN1190
      S2P   = AUXRL2-F3F2-F2F2-F1F2+ANTI2                               MAIN1200
      Z1    = Z1P+DEL1-RW                                               MAIN1390
      Z2    = Z2P+DEL2-RW                                               MAIN1400
      V1     = VO+A*RO-ZF*PO+Z1*PO                                      MAIN2060
      V2     = VO+A*RO-ZF*PO+Z2*PO                                      MAIN2070
      W1     = WO-A*QO+TF*0.5*PO-DEL1DT                                 MAIN2120
      W2     = WO-A*QO-TF*0.5*PO+DEL2DT                                 MAIN2130
      A005A =-DEL2DT/100.
      A007A = DEL2/10.
```

```
      A014A = DEL2DT/100.
      D007D =-DEL2DT/100.*BETA
      D005D = DEL2DD/1000.*BETA
      IF (AXLE.EQ.1) GOTO 400
*                                                                       MAIN 580
*    INDEPENDENT REAR
      DEL3   = 0.25
      DEL3DT = 69.0                                                     MAIN 540
      DEL3DD = SMP/AMS-TR*0.5*PDTO-B*QDTO+2./AMUR*(-FR3+S3-FYU3*...     MAIN1800
                 TAN(2.*HRC/TR))+G                                      MAIN1810
      DEL4  = .15
      DEL4DT = 70.0                                                     MAIN 560
      DEL4DD = SMP/AMS+TR*0.5*PDTO-B*QDTO+2./AMUR*(-FR4+S4+FYU4*...     MAIN1820
                 TAN(2.*HRC/TR))+G                                      MAIN1830
*
      F3R3   = 642.7
      F3R4   = 645.0
* ZET NOT DERIVED FROM INTEGRATION OF ZETDT
      ZET3=DEL3
      ZET3DT=DEL3DT
      ZET4=DEL4
      ZET4DT=DEL4DT
      F2R3   = AKR3*ZET3
      F2R4   = AKR4*ZET4
      S3P    =-F3R3-F2R3-F1R3+(DEL4-DEL3)*RR/TR**2+ANTI3
      S4P    =-F3R4-F2R4-F1R4-(DEL4-DEL3)*RR/TR**2+ANTI4
      Z3     = Z3P+DEL3-RW
      Z4     = Z4P+DEL4-RW
      V3      = VO-B*RO-ZR*PO+Z3*PO                                     MAIN2080
      V4      = VO-B*RO-ZR*PO+Z4*PO                                     MAIN2100
      W3      = WO-B*QO+DEL3DT+TR*0.5*PO
      W4      = WO+B*QO+DEL4DT-TR*0.5*PO
      A015A =-DEL4DT/100.
      A017A = DEL4/10.
      D015D = DEL4DD/1000.*BETA
      D017D =-DEL4DT/100.*BETA
400   CONTINUE
      SMP     = S1P + S2P + S3P + S4P                                   MAIN1270
      S1      = S1P+B*AMS*G/(2.*(A+B))                                  MAIN1280
      S2      = S2P+B*AMS*G/(2.*(A+B))                                  MAIN1290
      S3      = S3P+A*AMS*G/(2.*(A+B))                                  MAIN1300
      S4      = S4P+A*AMS*G/(2.*(A+B))                                  MAIN1310
*WHEEL ROTATIONAL EQUATIONS                                              MAIN1960
      UG1     = U1+THEO*W1                                              MAIN2180
      UG2     = U2+THEO*W2                                              MAIN2190
      UG3     = U3+THEO*W3                                              MAIN2200
      UG4     = U4+THEO*W4                                              MAIN2210
      VG1     = V1-PHIO*W1                                              MAIN2220
      VG2     = V2-PHIO*W2                                              MAIN2230
      VG3     = V3-PHIO*W3                                              MAIN2240
      VG4     = V4-PHIO*W4                                              MAIN2250
      UG1P   = UG1*COS(PSI1)+VG1*SIN(PSI1)                              MAIN2260
      UG2P   = UG2*COS(PSI2)+VG2*SIN(PSI2)                              MAIN2270
      UG3P = UG3+VG3*PSI3                                               MAIN2280
      UG4P   = UG4+VG4*PSI4                                             MAIN2290
      XI1     = 1.+RPS1*Z1/(UG1*COS(PSI1)+VG1*SIN(PSI1))                MAIN2300
      XI2     = 1.+RPS2*Z2/(UG2*COS(PSI2)+VG2*SIN(PSI2))                MAIN2310
      XI3     = 1.+RPS3*Z3/(UG3+VG3*PSI3)                               MAIN2320
      XI4     = 1.+RPS4*Z4/(UG4+VG4*PSI4)                               MAIN2330
*                                                                       MAIN2340
```

```
*WHEEL SLIP                                                                MAIN2350
                                                                           MAIN2360
      SLIP1  = XI1                                                         MAIN2370
      IF(ABS(XI1).GT.1.) SLIP1=SIGN(1.,XI1)                                MAIN2380
      SLIP2  = XI2                                                         MAIN2390
      IF(ABS(XI2).GT.1.) SLIP2=SIGN(1.,XI2)                                MAIN2400
      SLIP3  = XI3                                                         MAIN2410
      IF(ABS(XI3).GT.1.) SLIP3=SIGN(1.,XI3)                                MAIN2420
      SLIP4  = XI4                                                         MAIN2430
      IF(ABS(XI4).GT.1.) SLIP4=SIGN(1.,XI4)                                MAIN2440
* ### TIRE CIRCUMFERENTIAL FORCE ###                                       MAIN2450
*                                                                          MAIN2460
* EQUATIONS IN CFRIC PROGRAM, INCLUDE IN DSL AT A LATER TIME
*     U01   = U11-AM21                                                     MAIN2480
*     U02   = U12-AM22                                                     MAIN2490
*     U03   = U13-AM23                                                     MAIN2500
*     U04   = U14-AM24                                                     MAIN2510
      AM21   = U11-U01                                                     MAIN2520
      AM22   = U12-U02                                                     MAIN2530
      AM23   = U13-U03                                                     MAIN2540
      AM24   = U14-U04                                                     MAIN2550
      SI1    = U01/(AM11-AM21)                                             MAIN2560
      SI2    = U02/(AM12-AM22)                                             MAIN2570
      SI3    = U03/(AM13-AM23)                                             MAIN2580
      SI4    = U04/(AM14-AM24)                                             MAIN2590
      U1P   = AM21*SLIP1+U01                                               MAIN2600
      U2P   = AM22*SLIP2+U02                                               MAIN2610
      U3P   = AM23*SLIP3+U03                                               MAIN2620
      U4P   = AM24*SLIP4+U04                                               MAIN2630
      FC1    = -U1P*FR1                                                    MAIN2640
      FC2    = -U2P*FR2                                                    MAIN2650
      FC3    = -U3P*FR3                                                    MAIN2660
      FC4    = -U4P*FR4                                                    MAIN2670
      AIFBR = AIWF+AIDF*ARFBR*2.*.25
      AIFBRP= AIFBR-AIWF
      AIBR  = AIWR+AID*ARBR**2*0.25                                        MAIN2680
      AIBRP = AIBR-AIWR                                                    MAIN2690
      RPS1DT= (FC1*Z1+TQFBR*LB1)/AIWF                                      MAIN2700
      RPS2DT= (FC2*Z2+TQFBR*LB2)/AIWF                                      MAIN2710
      RPS3DT=-(-FC3*Z3-TQRBR*LB3+AIBRP*XPS4DT)/AIBR                        MAIN2720
      RPS4DT=-(-FC4*Z4-TQRBR*LB4+AIBRP*RPS3DT)/AIBR                        MAIN2730
*                                                                          MAIN2740
*SPARE TIRES                                                               MAIN2750
*                                                                          MAIN2760
      TIN    =1E-04                                                        MAIN2770
*                                                                          MAIN2760
```

```
                                                                    MAIN3270
*680 POTS
      P000     =DEL1DT/100.
      P001   = BETA/AMS*SFSF*10.                                        MAIN3430
      P016   = CFP/1000.0
      P018     =DEL3/10.                                                MAIN3460
      P019   = 2.0*CFP/10000.                                           MAIN3480
      P021   = BETA                                                     MAIN3490
      P022   = CFP/1000.                                                MAIN3510
      P024   = 2.0*CFP/10000.                                           MAIN3540
      P027   = CRP/1000.                                                MAIN3550
      P028   =  BETA                                                    MAIN3560
      P029   = 2.0*CRP/10000.
      P030     =DEL1/10.
      P043     =DEL3DT/100.                                             MAIN3700
      P049   = CRP/1000.                                                MAIN3710
      P050   = AIBRP/AIBR                                               MAIN3750
      P054   = 2.0*CRP/10000.                                           MAIN3760
      P055   = 100.*RWSF/3000.                                          MAIN3770
      P056    = 100.*RWSF/3000.                                         MAIN3780
      P058    = 100.*RWSF/3000.                                         MAIN3800
      P060   = 100./AKF1                                                MAIN3810
      P061   = 100./AKF2                                                MAIN3820
      P062   = 100./AKR3                                                MAIN3830
      P063   = 100./AKR4                                                MAIN3840
      P064   = SFSF                                                     MAIN3850
      P065   = SFSF                                                     MAIN3880
      P068   = SFSF                                                     MAIN3890
      P069   = SFSF                                                     MAIN3910
      P072   = 100.*RWSF/3000.                                          MAIN3920
      P073   = BETA                                                     MAIN3930
      P083   = RWSF*4.*AKT4/10000./AIBR*0.1                             MAIN3940
      P085   = BETA                                                     MAIN3950
      P086   = .2000                                                    MAIN3960
      P087   = 2./RWSF                                                  MAIN3970
      P088   = RW/RWSF                                                  MAIN4010
      P096   = .2000                                                    MAIN4030
      P098   = RW/RWSF                                                  MAIN4040
      P099   = 2./RWSF                                                  MAIN4050
      P100   = BETA                                                     MAIN4060
      P101   = RPS1/100.                                                MAIN4090
      P104   = RPS2/100.                                                MAIN4100
      P105   = BETA                                                     MAIN4110
      P106   = .2000                                                    MAIN4120
      P107   = 2./RWSF                                                  MAIN4130
      P108   = RW/RWSF                                                  MAIN4150
      P110   =  RPS3/100.                                               MAIN4160
      P111   = 4.0/AIBR*LB4                                             MAIN4170
      P112   = 4./AIBR*LB3                                              MAIN4180
      P113   = RWSF*4.*AKT3/10000./AIBR*0.1                             MAIN4190
      P114   = RPS4/100.
      P116   = .200                                                     MAIN4220
      P117   = 2./RWSF                                                  MAIN4230
      P118   = RW/RWSF                                                  MAIN4240
      P119   = AIBRP/AIBR
      IF(AXLE-1) 900,1000,1100
*     SOLID FRONT AXLE POTS
900    CONTINUE
      P002   = BETA/AMUF*SFSF
      P003   = TF/80.
```

```
      P008  = 20.*TSF/(2.*AIF)*BETA*SFSF*10.
      P025  = (1./2.5)*BETA
      P032  = (2.*AKT1/(10000.*AMUF))*BETA
      P034  =  BETA/AMUF*SFSF
      P037  = DEL2DT
      P038  = 4*DEL2
      P039  = .25*(ABS(RF))/(10000.*TSF)
      P044  = .25*(ABS(RF))/(10000.*TSF)
      P047  = TSF/200.
      P059  = TSF/200.
      P066  = .25*TSF/20.
      P067  = .25*TSF/20.
      P095  = 2.*AKT2/(10000.*AMUF)*BETA
      P097  = TF/80.
      P004  = 0.
      P005  = 0.
      P006  = 0.
      P007  = 0.
1000   CONTINUE
*    SOLID REAR AXLE POTS
      P009  = BETA/AMUR*SFSF
      P010  = AKT3/5000.0/AMUR*BETA                                     MAIN3380
      P011  = AKT4/5000.0/AMUR*BETA                                     MAIN3390
      P012  = BETA/AMS*SFSF*10.
      P013  = BETA*SFSF/AMUR
      P015  = 10.*TS/AIR*BETA*SFSF*10.
      P017  = 0.40*BETA                                                 MAIN3440
      P020  = 4.*DEL4
      P023  = DEL4DT
      P026  = ABS(RR)/4000./TS*.1                                       MAIN3530
      P035  = .01*TS/2.                                                 MAIN3600
      P036  = TS/2/40.0                                                 MAIN3610
      P045  = TS/2./40.                                                 MAIN3670
      P046  = .01*TS/2                                                  MAIN3680
      P053  = ABS(RR)/4000./TS*.1                                       MAIN3740
      P071  = 0.0                                                       MAIN3900
      P109  = TR/2./40.
      P115  = TR/2./40.
      P080  = 0.
      P081  = 0.
      P082  = 0.
      IF(IDRSW-1) 10,20,20
10    CONTINUE
      P051  = RWSF*4.*AKT1/10000./AIWF*0.1                              MAIN3720
      P052  = 4.0/AIWF*LB1                                              MAIN3730
      P090  = 0.0                                                       MAIN3980
      P091  = 0.0                                                       MAIN3990
      P102  = RWSF*4.*AKT2/10000./AIWF*0.1                              MAIN4070
      P103  = 4.0/AIWF*LB2                                              MAIN4080
      GOTO 30
20    CONTINUE
      P051  = RWSF*4.*AKT1/10000./AIFBR*.1
      P052  = 4./AIFBR*LB1
      P090  = AIFBRP/AIFBR
      P091  = AIFBRP/AIFBR
      P102  = RWSF*4.*AKT2/10000./AIFBR*.1
      P103  = 4./AIFBR*LB2
30    CONTINUE
      IF(AXLE.EQ.0) GOTO 1200
1100   CONTINUE
```

```
*      INDEPENDENT FRONT AXLE POTS
       P002  = 2./AMUF*BETA*SFSF
       P003  = 0.0
       P004 = .01*RF/TF**2*0.1
       P005  = 2.0*AKT2/5000.0/AMUF/1.0*BETA
       P006  = BETA/AMS*SFSF*10.
       P007  = 2./AMUF*BETA*SFSF
       P008  = 0.0
       P025  =  BETA
       P032  = 2.*AKT1/5000.0/AMUF*BETA
       P034  = 0.0
       P037    =DEL2DT/100.
       P038    =DEL2/10.
       P039  = 0.0
       P044  = 0.0
       P047  = 0.0
       P059  = 0.0
       P066  = 0.0
       P067  = 0.0
       P095  = 0.0
       P097  = 0.0
       IF(AXLE.EQ.1) GOTO 1200
*      INDEPENDENT REAR AXLE POTS
       P010  = AKT3*2./(5000.*AMUR)*BETA
       P012  = BETA/AMS*SFSF*10.
       P013  = 2./AMUR*BETA*SFSF
       P017  = BETA
       P020  = DEL4/10.
       P023  = DEL4DT/100.
       P071  = (RR/(100.*TR**2))
       P080  = AKT4*2./(5000.*AMUR)*BETA
       P081  = 2./AMUR*BETA*SFSF
       P082  = BETA/AMS*SFSF*10.
       P009  = 0.
       P011  = 0.
       P015  = 0.
       P026  = 0.
       P035  = 0.
       P036  = 0.
       P045  = 0.
       P046  = 0.
       P053  = 0.
       P109  = 0.
       P115  = 0.
1200    CONTINUE
*
       P000P = P000
       P001P = P001
       P002P = P002
       P003P = P003
       P004P = P004
       P005P = P005
       P006P = P006
       P007P = P007
       P008P = P008
       P009P = P009
       P010P = P010
       P011P = P011
       P012P = P012
       P013P = P013
```

```
P014P = P014
P015P = P015
P016P = P016
P017P = P017
P018P = P018
P019P = P019
P020P = P020
P021P = P021
P022P = P022
P023P = P023
P024P = P024
P025P = P025
P026P = P026
P027P = P027
P028P = P028
P029P = P029
P030P = P030
P031P = P031
P032P = P032
P033P = P033
P034P = P034
P035P = P035
P036P = P036
P037P = P037
P038P = P038
P039P = P039
P043P = P043
P044P = P044
P045P = P045
P046P = P046
P047P = P047
P049P = P049
P050P = P050
P051P = P051
P052P = P052
P053P = P053
P054P = P054
P055P = P055
P056P = P056
P057P = P057
P058P = P058
P059P = P059
P060P = P060
P061P = P061
P062P = P062
P063P = P063
P064P = P064
P065P = P065
P066P = P066
P067P = P067
P068P = P068
P069P = P069
P071P = P071
P072P = P072
P073P = P073
P080P = P080
P081P = P081
P082P = P082
P083P = P083
P086P = P086
```

```
      P087P = P087
      P088P = P088
      P090P = P090
      P091P = P091
      P095P = P095
      P096P = P096
      P097P = P097
      P098P = P098
      P099P = P099
      P101P = P101
      P102P = P102
      P103P = P103
      P104P = P104
      P105P = P105
      P106P = P106
      P107P = P107
      P108P = P108
      P109P = P109
      P110P = P110
      P111P = P111
      P112P = P112
      P113P = P113
      P114P = P114
      P115P = P115
      P116P = P116
      P117P = P117
      P118P = P118
      P119P = P119
*
TERMINAL
*
*
      DUMMY  =  DEBUG(1.,0.)
      CALL PUNCH
END
PARAM  AXLE  =1
END
PARAM AXLE= 2
END
STOP
```

```
*UNSCALED DAC VALUES FOR SYSTEM EQUATIONS                               MAIN2780
*                                                                       MAIN2790
      DAC00  = -MT1/AIFW+RDTO                                           MAIN2800
      DAC01  = RW+ZF+ZO-A*THEO+TF*0.5*PHIO                              MAIN2810
      DAC02  = -MT2/AIFW+RDTO                                           MAIN2820
      DAC03  = RW+ZF+ZO-A*THEO-TF*0.5*PHIO                              MAIN2830
      DAC08  = -TQFBR                                                   MAIN2900
      DAC09  = -TQRBR                                                   MAIN2910
      DAC16 = DELSWO/10.                                                MAIN2970
      DAC17  = RW+ZR+ZO+B*THEO+PHIO*TR*0.5                              MAIN2980
      DAC19  = RW+ZR+ZO+B*THEO-PHIO*TR*0.5                              MAIN2990
      DAC20 = AM23                                                      MAIN3000
      DAC21 = AM24                                                      MAIN3010
      DAC22 = AM21                                                      MAIN3020
      DAC23 = AM22                                                      MAIN3030
      DAC24  = UG1*COS(PSI1)+VG1*SIN(PSI1)                              MAIN3040
      DAC25  = UG2*COS(PSI2)+VG2*SIN(PSI2)                              MAIN3050
      DAC26  = UG3+VG3*PSI3                                             MAIN3060
      DAC28  = UG4+VG4*PSI4                                             MAIN3070
      DAC32  = U01                                                      MAIN3080
      DAC33  = U02                                                      MAIN3090
      DAC34 =U03                                                        MAIN3100
      DAC35  = U04                                                      MAIN3110
      DAC37 = ANTI1                                                     MAIN3120
      DAC38 = ANTI2                                                     MAIN3130
      DAC39 = ANTI3                                                     MAIN3140
      DAC40 = ANTI4                                                     MAIN3150
      IF(AXLE-1) 500,600,700
500    CONTINUE
*     SOLID FRONT
*      FOR SOLID FRONT AXLE, DEL2 IN DSL IS SAME AS PHIF IN EQUATIONS
      DAC04 = (TF*.5+Z1*DEL2)*AKT1/AIF
      DAC05 = A*QDTO+B*AMS*G/(A+B)/AMUF+G
      DAC06 = -(TF*.5+Z2*DEL2)*AKT2/AIF
      DAC07 =-PDTO+(-FYU1*(-Z1+TF*.5*DEL2)-FYU2*(-Z2-TF*.5*...
             DEL2)+FOTM)/AIF
      DAC07  = DAC07*100.
600    CONTINUE
*     SOLID REAR
*      FOR SOLID REAR AXLE, DEL4 IN DSL IS SAME AS PHIR IN EQUATIONS
      DAC12  = (+TR*0.5+Z3*DEL4)*AKT3/AIR
      DAC13 = G-B*QDTO+A*AMS*G/(A+B)/AMUR                               MAIN2930
      DAC14  =-(TR*0.5-Z4*DEL4)*AKT4/AIR
      DAC15  = -PDTO+(-(FYU3+FYU4)*HRC+ROTM...
                 -FYU3*(TR*0.5*DEL4-Z3)-FYU4*(-TR*0.5*DEL4-Z4))/AIR
      DAC15 = DAC15*100.
      IF(AXLE.EQ.0) GOTO 800
700    CONTINUE
*     INDEPENDENT FRONT
      DAC04 = 0                                                         MAIN2840
      DAC05  = -TF*0.5*PDTO+A*QDTO+B*AMS*G/((A+B)*AMUF)+G-2.*FYU1*...   MAIN2850
               TAN(2.*HFC/TF)/AMUF                                      MAIN2860
      DAC06 = 0                                                         MAIN2870
      DAC07  = TF*0.5*PDTO+A*QDTO+B*AMS*G/((A+B)*AMUF)+G+2.*FYU2*...    MAIN2880
               TAN(2.*HFC/TF)/AMUF                                      MAIN2890
      IF(AXLE.EQ.1) GOTO 800
*     INDEPENDENT REAR
      DAC12 = 0.
      DAC13 =-TR*.5*PDTO-B*QDTO+A*AMS*G/AMUR/(A+B)+G-FYU3...
```

```
               *(TAN(2.*HRC/TR))*2./AMUR
      DAC14 = 0.
      DAC15 = TR*.5*PDTO-B*QDTO+A*AMS*G/AMUR/(A+B)+G...
               +FYU4*(TAN(2.*HRC/TR))*2./AMUR
800    CONTINUE
*                                                                      MAIN3240
*                                                                      MAIN3250
*                                                                      MAIN4250
* SCALE FACTORS FOR D/A CONVERTERS                                     MAIN4260
*                                                                      MAIN4270
      DA00   = DAC00/10000.*BETA                                       MAIN4280
      DA01   = DAC01/10.                                               MAIN4290
      DA02   = DAC02/10000.*BETA                                       MAIN4300
      DA03   = DAC03/10.                                               MAIN4310
      DA04  = DAC04/100.*BETA
      DA05   = DAC05/10000.*BETA                                       MAIN4330
      DA06  = DAC06/100.*BETA
      DA07   = DAC07/10000.*BETA                                       MAIN4350
      DA08   = DAC08/40000.                                            MAIN4360
      DA09   = DAC09/40000.                                            MAIN4370
      DA12  = DAC12/100.*BETA                                          MAIN4380
      DA13   = DAC13/10000.*BETA                                       MAIN4390
      DA14  = DAC14/100.*BETA                                          MAIN4400
      DA15  = DAC15/10000.*BETA
      DA16  = DAC16/10.                                                MAIN4420
      DA17   = DAC17/10.                                               MAIN4430
      DA19  = DAC19/10.                                                MAIN4440
      DA20   = DAC20/(-20.)                                            MAIN4450
      DA21   = DAC21/(-20.)                                            MAIN4460
      DA22   = DAC22/(-20.)                                            MAIN4470
      DA23   = DAC23/(-20.)                                            MAIN4480
      DA24   = DAC24/1500.                                             MAIN4490
      DA25   = DAC25/1500.                                             MAIN4500
      DA26   = DAC26/1500.                                             MAIN4510
      DA28   = DAC28/1500.                                             MAIN4520
      DA32  = DAC32/(-2.)                                              MAIN4530
      DA33  = DAC33/(-2.)                                              MAIN4540
      DA34  = DAC34/(-2.)                                              MAIN4550
      DA35  = DAC35/(-2.)                                              MAIN4560
      DA37  = DAC37/10000.                                             MAIN4570
      DA38  = DAC38/10000.                                             MAIN4580
      DA39  = DAC39/10000.                                             MAIN4590
      DA40  = DAC40/10000.                                             MAIN4600
*  680 AMP'S                                                           MAIN4610
      A000   =-DEL1DT/100.                                             MAIN4620
      A001   = ZET1DT/100.                                             MAIN4630
      A002    =DEL1/10.                                                MAIN4640
      A004   =-DEL1/10.                                                MAIN4650
      A005   = A005A
      A006   = (S1P-S2P)/1000./2.                                      MAIN4670
      A007   = A007A
      A008   = Z1*RPS1/UG1P/2.                                         MAIN4690
      A010    =-DEL3DT/100.                                            MAIN4700
      A011   = ZET2DT/100.                                             MAIN4710
      A012    =DEL3/10.                                                MAIN4720
      A014   = A014A
      A015   = A015A
      A016    =-S1P/SCALE                                              MAIN4750
      A017   = A017A
      A018   =-Z1*RPS1/100./RWSF                                       MAIN4770
```

```
      A019    =S1P/SCALE
      A020    =SLIP4
      A021    =-S2P/SCALE
      A022    =RPS4DT/10000.
      A023   = U1P*FR1/AKT1/4.
      A024    =S2P/SCALE
      A026    =-S3P/SCALE
      A028   = (Z1*FR1*U1P)/(4*RWSF*AKT1)
      A029    =S3P/SCALE
      A030    =U3P/2.
      A031   =-F2F2/10000.
      A035    =ZET4DT/100.
      A036   =-F2R3/10000.
      A041    =U4P/2.
      A045   =-F2R4/10000.
      A046    =ZET3DT/100.
      A049   =  Z3/RWSF
      A051    =-S4P/SCALE
      A052   =-DEL3/10.
      A053   =-Z2*RPS2/RWSF/100.
      A054    =S4P/1000.
      A055   = (S3P-S4P)/1000./2.
      A056   = RPS1DT/10000.
      A059   = Z4/RWSF
      A060   = RPS2DT/10000.
      A062   = AUXRL1/10000.
      A063   =  (Z2*FR2*U2P)/4./RWSF/AKT2
      A065   =-(A004+A007)
      A066    =SMP/SCALE
      A068   = U2P*FR2/AKT2/4.
      A071   =-(A052+A017)
      A073   = Z3*RPS3/UG3P/2.
      A076    =RPS3DT/10000.
      A078   =-Z3*RPS3/RWSF/100.
      A081    =SLIP2
      A083    = (Z3*FR3*U3P)/(AKT3*4*RWSF)
      A084   = Z2/RWSF
      A086   =-FR1/AKT1/2.
      A088   = U3P*FR3/AKT3/4.
      A089   = Z1/RWSF
      A090   =-F2F1/10000.
      A091    =U1P/2.
      A092    =SLIP3
      A093   = Z2*RPS2/UG2P/2.
      A096   =-FR2/AKT2/2.
      A100   =-RPS1/100.
      A101    =SLIP1
      A103   = Z4*RPS4/UG4P/2.
      A105   =-RPS2/100.
      A106   =-FR3/AKT3/2.
      A108   =-Z4*RPS4/RWSF/100.
      A110    =-RPS3/100.
      A111    =U2P/2.
      A113    = (Z4*FR4*U4P)/(AKT4*4*RWSF)
      A115    =-RPS4/100.
      A116   =-FR4/AKT4/2.
      A118   = U4P*FR4/AKT4/4.
*    680 DERIVATIVES
      D000    =DEL1DD/1000.*BETA
      D002    =-DEL1DT/100.*BETA
```

```
      D005  = D005D
      D007  = D007D
      D010   =DEL3DD/1000.*BETA                                     MAIN5500
      D012   =-DEL3DT/100.*BETA                                     MAIN5510
      D015  = D015D
      D017 = D017D
      D100  = RPS1DT/1000.*BETA                                     MAIN5540
      D105  = RPS2DT/1000.*BETA                                     MAIN5550
      D110   =RPS3DT/1000.*BETA                                     MAIN5560
      D115   =RPS4DT/1000.*BETA                                     MAIN5570
*                                                                   MAIN3230
      T040  = ZET1DT/100.                                           MAIN5360
      T041  = ZET2DT/100.                                           MAIN5370
      T043  = ZET4DT/100.                                           MAIN5380
      T048  = DA16                                                  MAIN5340
      T049  = DA00                                                  MAIN5350
      T050  = DA02                                                  MAIN5390
      T053  = ZET3DT/100.                                           MAIN5400
      T80   =-F3F1/1000.
      T82   =-F3R3/1000.                                            MAIN5430
      T83   = -F3R4/1000.                                           MAIN5440
      T88   = -F3F2/1000.
TERMINAL                                                            MAIN3220
*                                                                   MAIN5580
*                                                                   MAIN5590
      DUMMY  =  DEBUG(1.,0.)                                        MAIN5600
      CALL PUNCH
END
PARAM  AXLE  =1                                                     MAIN 360
END
PARAM AXLE= 2
END                                                                 MAIN5620
STOP                                                                MAIN5630
```

```
*231-R AMP'S                                                        MAIN3140
*                                                                   MAIN3150
      A250   =YCRDT/200.                                            MAIN3160
      A251   =-YCR/3.                                               MAIN3170
      A260   =-DFW2DT/100.                                          MAIN3180
      A261   =2.*DFW2                                               MAIN3190
      A280   =-DFW1DT/100.                                          MAIN3200
      A281   =2.*DFW1                                               MAIN3210
      A227   =-.2*DFW2                                              MAIN3300
      A228  = DFW1
      A229  = DFW2
      A230  =-F3F1/1000.
      A231  =-F3F2/1000.
      A232  =-F3R3/1000.
      A233  =-F3R4/1000.
      A237   =-.2*DFW1                                              MAIN3350
      A238  =-(-MT1/AIFW+RDTO)*BETA/10000.
      A239  =-(-MT2/AIFW+RDTO)*BETA/10000.
      A240  = -ZET1DT/100.
      A241  = -ZET2DT/100.
      A242   =-ZET3DT/100.                                          MAIN3400
      A243   =ZET3DT/100.                                           MAIN3410
      A244   =-ZET4DT/100.                                          MAIN3420
      A245   =ZET4DT/100.                                           MAIN3430
      A247  =-A240
      A248  =-A241
      A252  = -YCRDD*AMCR/40000.
      A254  = -1.0
      A262   =-2.*(DFW2-(YCR/AA2))                                  MAIN3470
      A263   =2.*AMSS2/AKSL2                                        MAIN3480
      A264   =-A263                                                 MAIN3490
      A270   = -(DELSWO-(ANG*YCR)/AP)/10.                           MAIN3500
      A271  = ESP/2
      A272   =-(A270+A271*.100)                                     MAIN3520
      A273   =-A250                                                 MAIN3530
      A274  = -DELSWO/10.
      A282   =-2.*(DFW1-(YCR/AA1))                                  MAIN3540
      A283   =2.*AMSS1/AKSL1                                        MAIN3550
      A284   =-A283                                                 MAIN3560
      A292  = 20.*EP1/2.
      A293  = 20.*EP2/2.
*     THE FOLLOWING CALCULATIONS
*     FOR INDEPENDENT MACHINE SETUP
      A210  = A230
      A211  = A231
      A212  = A232
      A213  = A233
      A215  = (MT1/AIFW+RDTO)*BETA/100000.
      A216  = DELSWO/100.
      A217  = (MT2/AIFW+RDTO)*BETA/100000.
      A218  =-(2.*DFW1)
      A219  = -(2.*DFW2)
```

```
*231 DERIVATIVES                                                        MAIN3600
*                                                                       MAIN3610
      D250    =YCRDD/20000.*BETA                                        MAIN3620
      D251    =-YCRDT/30.*BETA                                          MAIN3630
      D260    =-DFW2DD/1000.*BETA                                       MAIN3640
      D261    =DFW2DT/5.*BETA                                           MAIN3650
      D280    =-DFW1DD/1000.*BETA                                       MAIN3660
      D281    =DFW1DT/5.*BETA                                           MAIN3670
* 231-R POTS                                                            MAIN2660
      DAC00 =-MT1/AIFW+RDTO
      DAC16 =DELSWO/10.
      DAC02 =-MT2/AIFW+RDTO
*                                                                       MAIN2670
      Q202   = 2.0/(20.0*AMCR)*BETA
      Q204    = 2.0/3.0*BETA                                            MAIN2720
      Q205     =YCRDT/200.                                              MAIN2730
      Q206     =YCR/3.                                                  MAIN2740
      Q208     =DFW2DT/100.                                             MAIN2760
      Q209     =2.*DFW2                                                 MAIN2770
      Q212    = AH2/(100.0*AIFW)*BETA                                   MAIN2800
      Q214    = AKSL2/(40000.0*AIFW)*BETA                               MAIN2820
      Q219    =(AKSC*ANG/(AP*2000.0))/20.                               MAIN2860
      Q222    = AH1/(100.0*AIFW)*BETA                                   MAIN2890
      Q224    = AKSL1/(40000.0*AIFW)*BETA                               MAIN2910
      Q235     =DFW1DT/100.                                             MAIN2920
      Q236     =2.*DFW1                                                 MAIN2930
      Q257   = CFCR/(2.*10000.)
      Q258    = CCR/100.0                                               MAIN2970
      Q267   = AKSL2/AA2/400000.
      Q268    =3.0/AA2                                                  MAIN3010
      Q277 = .10000
      Q287    =3.0/AA1                                                  MAIN3060
      Q288   = AKSL1/AA1/400000.
      P215    =.9999*BETA                                               MAIN3090
      P217   = .30*ANG/(10.0*AP)
      P230    =.9999*BETA                                               MAIN3120
      P235   = .1000
      P236   = .1000
      P237   = .1000
*     THE FOLLOWING CALCULATIONS
*     FOR INDEPENDENT MACHINE SETUP
      P210   = F3F1/DEL1DT/10.
      P211   = F3F2/DEL2DT/10.
      Q212   = F3R3/ZET3DT/10.
      P213   = F3R4/ZET4DT/10.
      Q215   =-DAC00/100000.*BETA
      Q216   = DAC16/10.
      Q217   =-DAC02/100000.*BETA
      Q218   = 2.*DFW1
      P219   = 2.*DFW2
*
TERMINAL
*
      DUMMY   =   DEBUG(1.,0.)
END
STOP
```

```
          *** DSL/91  SIMULATION DATA ***                                              76.167        20:12:09.52
TITLE === PROB 52 VEHICLE SIMULATION ===
INCON  DFW2DT=37.    ,DFW2   =0.15  ,YCRDT =B0.    ,YCR    =2.55
INCON  RPS1   =43.06 ,RPS2   =43.06 ,RPS3  =43.057,XPS2DT=10000.
INCON  RPS4   =43.057,XPS4DT=10000.,DFW1DT=30.    ,DFW1   =0.35
INCON  PSI1   =.2140 ,PSI2   =.2040 ,PSI3  =.01667,PSI4   =-.0150
INCON  ZO     =-23.4 ,THEO   =.00209,PHIO  =.00300,RDTO   =-500.0
INCON  U01    =.120  ,U02    =1.01  ,U03   =.900  ,U04    =1.250
INCON  U11    =-.6133,U12    =1.11  ,U13   =1.621 ,U14    =1.700
INCON  AM11   =5.25  ,AM12   =-7.40 ,AM13  =-7.50 ,AM14   =-B.30
INCON  TQFBR  =8000. ,TQRBR  =7100. ,MT1   =-164.3,MT2    =164.3
INCON  PDTO   =-.12  ,QDTO   =.0900 ,UO    =704.  ,VO     =.1300
INCON  WO     =.0050 ,PO     =.0200 ,QO    =-.0370,RO     =.0110
INCON  F1     =.9    ,F2     =.8    ,F3    =-.3   ,F4     =.6
INCON  GB1    =.2    ,GB2    =.4    ,GB3   =.5    ,GB4    =.85
PARAM  AMS    =5.162 ,AMUF   =0.359 ,AMUR  =0.574 ,TS     = 35.B6
PARAM  AIR    =800.  ,RF     =B1E03 ,TF    =54.3  ,RR     =50E03
PARAM  RW     =12.B5 ,AIFW   =5.815 ,AH1   =200.  ,AH2    =200.
PARAM  AKT1   =B12.  ,AKT2   =B12.  ,AKT3  =1192. ,AKT4   =1192.
PARAM  AMCR   =0.08  ,CFCR   =200.  ,CCR   =11.   ,AP     =6.06
PARAM  AA1    =5.53  ,AA2    =5.53  ,ANG   =17.5  ,AKSC   =610.
PARAM  ESP    =-.6   ,AKSL1 =1.17E5,AKSL2 =1.17E5,EP1    =-.0200
PARAM  EP2    =-.01  ,AIWF   =7.3777,AID   =0.3   ,ARBR   =4.125
PARAM  AIWR   =7.3777,CFP    =25.   ,CRP   =45.   ,TR     =53.3
PARAM  AKF1   =150.  ,AKF2   =150.  ,AKR3  =200.  ,AKR4   =200.
PARAM  A      =56.3  ,B      =39.0  ,G     =3B6.4 ,ZF     =10.B
PARAM  ZR     =10.6  ,AMU1   =.1795 ,AMU2  =.1795 ,AMU3   =.2870
PARAM  HRC    =4.70  ,CRRC   =0.0110,TANP  =0.0   ,DELSWO=1.425
PARAM  LB1    =1.65  ,LB2    =1.65  ,LB3   =1.0   ,LB4    =1.0
PARAM  AIDF   = .7   ,ARFBR  = 2.7  ,AIF   = 498. ,TSF    = 32.25
PARAM  AMU4   =.2870 ,FOTM   = 250. ,ROTM  = 400. ,HFC    =7.20
PARAM SCALE = 1000. ,RWSF   =20.
PARAM    AXLE= 0
PARAM    IDULTR= 0
PARAM    IDRSW= 0
PARAM  BETA   =0.25
CONTRL TSTART=0.0,FINTIM=.002,DELT=.001
END

***DSL MESSAGE 20***    NO OUTPUT REQUESTED...WARNING ONLY.

DSL/91  SIMULATION TIME=   0.01 SECONDS.                                               76.167        20:12:10.09

 DEBUG OUTPUT, BLOCK    3 AT TIME=  0.2000E-02
```

TIME	2.0000E-03	DELT	1.0000E-03	DELMIN	0.0	DELMAX	7.2370E 75	TSTART	0.0	FINTIM	2.0000E-03
CLKTIM	0.0	NALARM	0.0	DELS	0.0	DELNIX	7.2370E 75	DELADC	7.2370E 75	DELDAC	7.2370E 75
DELSTP	7.2370E 75	DELMRK	7.2370E 75	DFW2DT	3.7000E 01	DFW2	1.5000E-01	YCRDT	8.0000E 01	YCR	2.5500E 00
RPS1	4.3060E 01	RPS2	4.3060E 01	RPS3	4.3057E 01	XPS2DT	1.0000E 04	RPS4	4.3057E 01	XPS4DT	1.0000E 04
DFW1DT	3.0000E 01	DFW1	3.5000E-01	PSI1	2.1400E-01	PSI2	2.0400E-01	PSI3	1.6670E-02	PSI4	-1.5000E-02
ZO	-2.3400E 01	THEO	2.0900E-03	PHIO	3.0000E-03	RDTO	-5.0000E 02	U01	1.2000E-01	U02	1.0100E 00
'103	9.0000E-01	U04	1.2500E 00	U11	-6.1330E-01	U12	1.1100E 00	U13	1.6210E 00	U14	1.7000E 00
AM11	5.2500E 00	AM12	-7.4000E 00	AM13	-7.5000E 00	AM14	-B.3000E 00	TQFBR	8.0000E 03	TQRBR	7.1000E 03
MT1	-1.6430E 02	MT2	1.6430E 02	PDTO	-1.2000E-01	QDTO	9.0000E-02	UO	7.0400E 02	VO	1.3000E-01
WO	5.0000E-03	PO	2.0000E-02	QO	-3.7000E-02	RO	1.1000E-02	F1	9.0000E-01	F2	8.0000E-01
F3	-3.0000E-01	F4	6.0000E-01	GB1	2.0000E-01	GB2	4.0000E-01	GB3	5.0000E-01	GB4	8.5000E-01
AMS	5.1620E 00	AMUF	3.5900E-01	AMUR	5.7400E-01	TS	3.5860E 01	AIR	8.0000E 02	RF	8.1000E 04
TF	5.4300E 01	RR	5.0000E 04	RW	1.2B50E 01	AIFW	5.B150E 00	AH1	2.0000E 02	AH2	2.0000E 02
AKT1	8.1200E 02	AKT2	B.1200E 02	AKT3	1.1920E 03	AKT4	1.1920E 03	AMCR	B.0000E-02	CFCR	2.0000E 02
CCR	1.1000E 01	AP	6.0600E 00	AA1	5.5300E 00	AA2	5.5300E 00	ANG	1.7500E 01	AKSC	6.1000E 02

ESP	-6.0000E-01	AKSL1	1.1700E 05	AKSL2	1.1700E 05	EP1	-2.0000E-02	EP2	-1.0000E-02	AIWF	7.3777E 00
AID	3.0000E-01	ARBR	4.1250E 00	AIWR	7.3777E 00	CFP	2.5000E 01	CRP	4.5000E 01	TR	5.3300E 01
AKF1	1.5000E 02	AKF2	1.5000E 02	AKR3	2.0000E 02	AKR4	2.0000E 02	A	5.6300E 01	B	3.9000E 01
G	3.8640E 02	ZF	1.0800E 01	ZR	1.0600E 01	AMU1	1.7950E-01	AMU2	1.7950E-01	AMU3	2.8700E-01
HRC	4.7000E 00	CRRC	1.1000E-02	TANP	0.0	DELSWO	1.4250E 00	L81	1.6500E 00	L82	1.6500E 00
LB3	1.0000E 00	LB4	1.0000E 00	AIDF	7.0000E-01	ARF8R	2.7000E 00	AIF	4.9800E 02	TSF	3.2250E 01
AMU4	2.8700E-01	FOTM	2.5000E 02	ROTM	4.0000E 02	HFC	7.2000E 00	SCALE	1.0000E 03	RWSF	2.0000E 01
AXLE	0.0	IDULTR	0.0	IDRSW	0.0	BETA	2.5000E-01	ZZ0001	0.0	F1F1	2.5000E 01
F1F2	-2.5000E 01	F1R3	4.5000E 01	F1R4	4.5000E 01	ANTI1	4.5000E 02	ANTI2	3.0000E 02	ANTI3	3.5000E 02
ANTI4	5.0000E 02	AUXRL1	-1.3324E 01	AUXRL2	1.3324E 01	Z1P	2.1378E-01	Z2P	5.0883E-02	Z3P	2.1147E-01
Z4P	5.1577E-02	FR1	9.1028E 02	ZZ0002	0.0	FR2	1.1663E 02	FR3	1.8077E 03	FR4	4.1310E 02
FXU1	6.0307E 01	FXU2	-1.1879E 02	FXU3	-2.0205E 03	FXU4	-5.5828E 02	FYU1	4.0060E 01	FYU2	-1.8134E 01
FYU3	-1.1700E 02	FYU4	6.7620E 01	NPHIF	-2.6313E 04	NPHIR	-4.4863E 04	TP	-6.0195E 04	AMSS1	-1.1831E 04
AMSS2	-3.5816E 04	DFW1DD	1.4745E 03	DFW2DD	5.4149E 03	YCRDD	-2.4537E 05	SFSF	1.0000E-01	U1	7.0330E 02
U2	7.0390E 02	U3	7.0331E 02	U4	7.0390E 02	DEL1	5.0000E-01	DEL1DT	5.0000E 00	DEL1DD	1.0947E 03
DEL2	1.5000E-02	DEL2DT	9.5000E-01	DEL2DD	-5.2564E 01	ZET1	7.4187E-01	ZET2	2.5813E-01	ZET1DT	2.0319E 01
ZET2DT	-1.0319E 01	F2F1	1.1128E 02	F2F2	3.8719E 01	F3F1	2.0150E 02	F3F2	-4.1100E 01	F4F1	-3.7674E 01
F4F2	3.7674E 01	S1P	7.4545E 01	S2P	3.6506E 02	Z1	-1.1729E 01	Z2	-1.2706E 01	V1	-1.0609E 01
V2	-1.1792E 01	W1	3.3424E 01	W2	-1.9247E 01	A005A	-9.5000E-01	A007A	6.0000E-02	A014A	9.5000E-01
D005D	-1.3141E 00	D007D	-9.5000E-02	DEL3	8.0000E-01	DEL3DT	2.0000E 01	DEL3DD	-1.5445E 03	DEL4	1.8950E-02
DEL4DT	5.5000E-01	DEL4DD	-5.6191E 01	ZET3	1.1398E 00	ZET4	4.6023E-01	ZET3DT	2.9861E 01	ZET4DT	1.0139E 01
F2R3	2.2795E 02	F2R4	9.2045E 01	F3R4	1.9590E 02	F3R3	3.4560E 02	S3P	-2.9498E 02	S4P	1.9348E 02
Z3	-1.1334E 01	Z4	-1.2503E 01	V3	-6.9711E 00	V4	-7.1378E 00	W3	3.6638E 01	W4	3.3715E 00
A015A	-5.5000E-01	A017A	7.5800E-02	D017D	-5.5000E-02	D015D	-1.4048E 00	SMP	3.3810E 02	S1	4.8267E 02
S2	7.7318E 02	S3	2.9419E 02	S4	7.8265E 02	UG1	7.0337E 02	UG2	7.0386E 02	UG3	7.0339E 02
UG4	7.0391E 02	VG1	-1.0709E 01	VG2	-1.1734E 01	VG3	-7.0810E 00	VG4	-7.1479E 00	UG1P	6.8505E 02
UG2P	6.8689E 02	UG3P	7.0327E 02	UG4P	7.0401E 02	XI1	2.6276E-01	XI2	2.0345E-01	XI3	3.0612E-01
XI4	2.3530E-01	SLIP1	2.6276E-01	SLIP2	2.0345E-01	SLIP3	3.0612E-01	SLIP4	2.3530E-01	AM21	-7.3330E-01
AM22	1.0000E-01	AM23	7.2100E-01	AM24	4.5000E-01	SI1	2.0056E-02	SI2	-1.3467E-01	SI3	-1.0948E-01
SI4	-1.4286E-01	U1P	-7.2681E-02	U2P	1.0303E 00	U3P	1.1207E 00	U4P	1.3559E 00	FC1	6.6160E 01
FC2	-1.2017E 02	FC3	-2.0259E 03	FC4	-5.6011E 02	AIF8R	8.3227E 00	AIF8RP	9.4500E-01	AI8R	8.6539E 00
AI8RP	1.2762E 00	RPS1DT	1.6840E 03	RPS2DT	1.9961E 03	RPS3DT	1.9989E 03	RPS4DT	1.3349E 03	TIN	1.0000E-04
DAC00	-4.7175E 02	DAC01	2.1378E-01	DAC02	-5.2825E 02	DAC03	5.0883E-02	DAC08	-8.0000E 03	DAC09	-7.1000E 03
DAC16	1.4250E-01	DAC17	2.1146E-01	DAC19	5.1563E-02	DAC20	7.2100E-01	DAC21	4.5000E-01	DAC22	-7.3330E-01
DAC23	1.0000E-01	DAC24	6.8505E 02	DAC25	6.8689E 02	DAC26	7.0327E 02	DAC28	7.0401E 02	DAC32	1.2000E-01
DAC33	1.0100E 00	DAC34	9.0000E-01	DAC35	1.2500E 00	DAC37	4.5000E 02	DAC38	3.0000E 02	DAC39	3.5000E 02
DAC40	5.0000E 02	DAC04	4.3982E 01	DAC05	2.6652E 03	DAC06	-4.3958E 01	DAC07	9.3624E 00	DAC12	3.9388E 01
DAC13	2.4357E 03	DAC14	-4.0062E 01	DAC15	1.6273E 02	DA00	-1.1794E-02	DA01	2.1378E-02	DA02	-1.3206E-02
DA03	5.0883E-03	DA04	1.0995E-01	DA05	6.6629E-02	DA06	-1.0989E-01	DA07	2.3406E-04	DA08	-2.0000E-01
DA09	-1.7750E-01	DA12	9.8471E-02	DA13	6.0894E-02	DA14	-1.0015E-01	DA15	4.0683E-03	DA16	1.4250E-02
DA17	2.1146E-02	DA19	5.1563E-03	DA20	-3.6050E-02	DA21	-2.2500E-02	DA22	3.6665E-02	DA23	-5.0000E-03
DA24	4.5670E-01	DA25	4.5792E-01	DA26	4.6885E-01	DA28	4.6934E-01	DA32	-6.0000E-02	DA33	-5.0500E-01
DA34	-4.5000E-01	DA35	-6.2500E-01	DA37	4.5000E-02	DA38	3.0000E-02	DA39	3.5000E-02	DA40	5.0000E-02
A000	-5.0000E-02	A001	2.0319E-01	A002	5.0000E-02	A004	-5.0000E-02	A005	-9.5000E-01	A006	-1.4526E-01
A007	6.0000E-02	A008	-3.6862E-01	A010	-2.0000E-01	A011	-1.0319E-01	A012	8.0000E-02	A014	9.5000E-01
A015	-5.5000E-01	A016	-7.4545E-02	A017	7.5800E-02	A018	2.5252E-01	A019	7.4545E-02	A020	2.3530E-01
A021	-3.6506E-01	A022	1.3349E-01	A023	-2.0369E-02	A024	3.6506E-01	A026	2.9498E-01	A028	1.1946E-02
A029	-2.9498E-01	A030	5.6036E-01	A031	-3.8719E-03	A035	1.0138E-01	A036	-2.2795E-02	A041	6.7794E-01
A045	-9.2045E-03	A046	2.9861E-01	A049	-5.6668E-01	A051	-1.9348E-01	A052	-8.0000E-02	A053	2.7357E-01
A054	1.9348E-01	A055	-2.4423E-01	A056	1.6840E-01	A059	-6.2517E-01	A060	1.9961E-01	A062	-1.3324E-03
A063	-2.3506E-02	A065	-1.0000E-02	A066	3.3810E-01	A068	3.6998E-02	A071	4.2000E-03	A073	-3.4694E-01
A076	1.9989E-01	A078	2.4399E-01	A081	2.0345E-01	A083	-2.4077E-01	A084	-6.3532E-01	A086	-5.6052E-01
A088	4.2489E-01	A089	-5.8645E-01	A090	-1.1128E-02	A091	-3.6340E-02	A092	3.0612E-01	A093	-3.9827E-01
A096	-7.1817E-02	A100	-4.3060E-01	A101	2.6276E-01	A103	-3.8235E-01	A105	-4.3060E-01	A106	-7.5824E-01
A108	2.6918E-01	A110	-4.3057E-01	A111	5.1517E-01	A113	-7.3441E-02	A115	-4.3057E-01	A116	-1.7328E-01
A118	1.1747E-01	D000	2.7367E-01	D002	-1.2500E-02	D005	-1.3141E 00	D007	-9.5000E-02	D010	-3.8612E-01
D012	-5.0000E-02	D015	-1.4048E 00	D017	-5.5000E-02	D100	4.2100E-01	D105	4.9903E-01	D110	4.9973E-01
D115	3.3373E-01	T040	2.0319E-01	T041	-1.0319E-01	T043	1.0138E-01	T048	1.4250E-02	T049	-1.1794E-02
T050	-1.3206E-02	T053	2.9861E-01	T80	-2.0150E-01	T82	-3.4560E-01	T83	-1.9590E-01	T88	4.1100E-02
ZZ0003	0.0	ZZ0004	0.0	DUMMY	0.0						

```
               *** DSL/91  SIMULATION DATA ***                                        76.167        20:12:18.59
      PARAM   AXLE  =1
      END

***DSL MESSAGE 20***    NO OUTPUT REQUESTED...WARNING ONLY.

DSL/91  SIMULATION TIME=   0.01 SECONDS.                                               76.167        20:12:18.61

 DEBUG OUTPUT, BLOCK   3 AT TIME=  0.2000E-02
```

TIME	2.0000E-03	DELT	1.0000E-03	DELMIN	0.0	DELMAX	7.2370E 75	TSTART	0.0	FINTIM	2.0000E-03
CLKTIM	0.0	NALARM	0.0	DELS	0.0	DELNIX	7.2370E 75	DELADC	7.2370E 75	DELDAC	7.2370E 75
DELSTP	7.2370E 75	DELMRK	7.2370E 75	DFW2DT	3.7000E 01	DFW2	1.5000E-01	YCRDT	8.0000E 01	YCR	2.5500E 00
RPS1	4.3060E 01	RPS2	4.3060E 01	RPS3	4.3057E 01	XPS2DT	1.0000E 04	RPS4	4.3057E 01	XPS4DT	1.0000E 04
DFW1DT	3.0000E 01	DFW1	3.5000E-01	PSI1	2.1400E-01	PSI2	2.0400E-01	PSI3	1.6670E-02	PSI4	-1.5000E-02
ZO	-2.3400E 01	THEO	2.0900E-03	PHIO	3.0000E-03	RDTO	-5.0000E 02	U01	1.2000E-01	U02	1.0100E 00
U03	9.0000E-01	U04	1.2500E 00	U11	-6.1330E-01	U12	1.1100E 00	U13	1.6210E 00	U14	1.7000E 00
AM11	5.2500E 00	AM12	-7.4000E 00	AM13	-7.5000E 00	AM14	-8.3000E 00	TQFBR	8.0000E 03	TQR8R	7.1000E 03
MT1	-1.6430E 02	MT2	1.6430E 02	PDTO	-1.2000E-01	QDTO	9.0000E-02	UO	7.0400E 02	VO	1.3000E-01
WO	5.0000E-03	PO	2.0000E-02	QO	-3.7000E-02	RO	1.1000E-02	F1	9.0000E-01	F2	8.0000E-01
F3	-3.0000E-01	F4	6.0000E-01	G81	2.0000E-01	G82	4.0000E-01	GB3	5.0000E-01	GB4	8.5000E-01
AMS	5.1620E 00	AMUF	3.5900E-01	AMUR	5.7400E-01	TS	3.5860E 01	AIP	8.0000E 02	RF	8.1000E 04
TF	5.4300E 01	RR	5.0000E 04	RW	1.2850E 01	AIFW	5.8150E 00	AH1	2.0000E 02	AH2	2.0000E 02
AKT1	8.1200E 02	AKT2	8.1200E 02	AKT3	1.1920E 03	AKT4	1.1920E 03	AMCR	8.0000E-02	CFCR	2.0000E 02
CCR	1.1000E 01	AP	6.0600E 00	AA1	5.5300E 00	AA2	5.5300E 00	ANG	1.7500E 01	AKSC	6.1000E 02
ESP	-6.0000E-01	AKSL1	1.1700E 05	AKSL2	1.1700E 05	EP1	-2.0000E-02	EP2	-1.0000E-02	AIWF	7.3777E 00
AID	3.0000E-01	AR8R	4.1250E 00	AIWR	7.3777E 00	CFP	2.5000E 01	CRP	4.5000E 01	TR	5.3300E 01
AKF1	1.5000E 02	AKF2	1.5000E 02	AKR3	2.0000E 02	AKR4	2.0000E 02	A	5.6300E 01	8	3.9000E 01
G	3.8640E 02	ZF	1.0800E 01	ZR	1.0600E 01	AMU1	1.7950E-01	AMU2	1.7950E-01	AMU3	2.8700E-01
HRC	4.7000E 00	CRRC	1.1000E-02	TANP	0.0	DELSWO	1.4250E 00	LB1	1.6500E 00	LB2	1.6500E 00
L83	1.0000E 00	L84	1.0000E 00	AIDF	7.0000E-01	ARFBR	2.7000E 00	AIF	4.9800E 02	TSF	3.2250E 01
AMU4	2.8700E-01	FOTM	2.5000E 02	ROTM	4.0000E 02	HFC	7.2000E 00	SCALE	1.0000E 03	RWSF	2.0000E 01
AXLE	1.0000E 00	IDULTR	0.0	IDRSW	0.0	BETA	2.5000E-01	ZZ0001	0.0	F1F1	2.5000E 01
F1F2	2.5000E 01	F1R3	4.5000E 01	F1R4	4.5000E 01	ANTI1	4.5000E 02	ANTI2	3.0000E 02	ANTI3	3.5000E 02
ANTI4	5.0000E 02	AUXRL1	4.0740E 01	AUXRL2	-4.0740E 01	Z1P	2.1378E-01	Z2P	5.0883E-02	Z3P	2.1147E-01
Z4P	5.1577E-02	FR1	4.8459E 02	ZZ0002	0.0	FR2	1.5565E 03	FR3	1.8077E 03	FR4	4.1310E 02
FXU1	2.1540E 01	FXU2	-1.6027E 03	FXU3	-2.0205E 03	FXU4	-5.5828E 02	FYU1	1.9030E 01	FYU2	-2.4560E 02
FYU3	-1.1700E 02	FYU4	6.7620E 01	NPHIF	6.8758E 04	NPHIR	-4.4863E 04	TP	-6.0195E 04	AMSS1	-1.1831E 04
AMSS2	-3.5816E 04	DFW1DD	1.4745E 03	DFW2DD	5.4149E 03	YCRDD	-2.4537E 05	SFSF	1.0000E-01	U1	7.0330E 02
U2	7.0390E 02	U3	7.0331E 02	U4	7.0390E 02	DEL1	3.8300E-01	DEL1DT	1.0000E 01	DEL1DD	1.4017E 03
DEL2	1.8660E 00	DEL2DT	1.5000E 01	DEL2DD	-6.8627E 03	ZET1	3.8300E-01	ZET2	1.8660E 00	ZET1DT	1.0000E 01
ZET2DT	1.5000E 01	F2F1	5.7450E 01	F2F2	2.7990E 02	F3F1	1.4400E 02	F3F2	1.7230E 02	F4F1	-3.7674E 01
F4F2	3.7674E 01	S1P	2.6429E 02	S2P	-2.1794E 02	Z1	-1.2253E 01	Z2	-1.0933E 01	V1	2.8824E-01
V2	3.1464E-01	W1	-7.3689E 00	W2	1.6545E 01	A005A	-1.5000E-01	A007A	1.8660E-01	A014A	1.5000E-01
D005D	-1.7157E 00	D007D	-3.7500E-02	DEL3	8.0000E-01	DEL3DT	2.0000E 01	DEL3DD	-1.6207E 03	DEL4	1.8950E-02
DEL4DT	5.5000E-01	DEL4DD	-5.6191E 01	ZET3	1.1398E 00	ZET4	4.6023E-01	ZET3DT	2.9861E 01	ZET4DT	1.0139E 01
F2R3	2.2795E 02	F2R4	9.2045E 01	F3R4	1.9590E 02	F3R3	3.4560E 02	S3P	-2.9498E 02	S4P	1.9348E 02
Z3	-1.1334E 01	Z4	-1.2503E 01	V3	-6.9711E 00	V4	-7.1378E 00	W3	3.6638E 01	W4	3.3715E 00
A015A	-5.5000E-01	A017A	7.5800E-02	D017D	-5.5000E-02	D015D	-1.4048E 00	SMP	-5.5149E 01	S1	6.7242E 02
S2	1.9019E 02	S3	2.9419E 02	S4	7.8265E 02	UG1	7.0329E 02	UG2	7.0393E 02	UG3	7.0339E 02
UG4	7.0391E 02	VG1	3.1034E-01	VG2	2.6500E-01	VG3	-7.0810E 00	VG4	-7.1479E 00	UG1P	6.8731E 02
UG2P	6.8939E 02	UG3P	7.0327E 02	UG4P	7.0401E 02	XI1	2.3233E-01	XI2	3.1711E-01	XI3	3.0612E-01
XI4	2.3530E-01	SLIP1	2.3233E-01	SLIP2	3.1711E-01	SLIP3	3.0612E-01	SLIP4	2.3530E-01	AM21	-7.3330E-01
AM22	1.0000E-01	AM23	7.2100E-01	AM24	4.5000E-01	SI1	2.0056E-02	SI2	-1.3467E-01	SI3	-1.0948E-01
SI4	-1.4286E-01	U1P	-5.0371E-02	U2P	1.0417E 00	U3P	1.1207E 00	U4P	1.3559E 00	FC1	2.4409E 01
FC2	-1.6214E 03	FC3	-2.0259E 03	FC4	-5.6011E 02	AIFBR	8.3227E 00	AIFBRP	9.4500E-01	AIBR	8.6539E 00
AI8RP	1.2762E 00	RPS1DT	1.7486E 03	RPS2DT	4.1920E 03	RPS3DT	1.9989E 03	RPS4DT	1.3349E 03	TIN	1.0000E-04
DAC00	-4.7175E 02	DAC01	2.1378E-01	DAC02	-5.2825E 02	DAC03	5.0883E-02	DAC08	-8.0000E 03	DAC09	-7.1000E 03
DAC16	1.4250E-01	DAC17	2.1146E-01	DAC19	5.1563E-02	DAC20	7.2100E-01	DAC21	4.5000E-01	DAC22	-7.3330E-01
DAC23	1.0000E-01	DAC24	6.8731E 02	DAC25	6.8939E 02	DAC26	7.0327E 02	DAC28	7.0401E 02	DAC32	1.2000E-01

DAC33	1.0100E 00	DAC34	9.0000E-01	DAC35	1.2500E 00	DAC37	4.5000E 02	DAC38	3.0000E 02	DAC39	3.5000E 02
DAC40	5.0000E 02	DAC04	0.0	DAC05	2.6396E 03	DAC06	0.0	DAC07	3.0335E 03	DAC12	3.9388E 01
DAC13	2.4357E 03	DAC14	-4.0062E 01	DAC15	1.6273E 02	DA00	-1.1794E-02	DA01	2.1378E-02	DA02	-1.3206E-02
DA03	5.0883E-03	DA04	0.0	DA05	6.5991E-02	DA06	0.0	DA07	7.5838E-02	DA08	-2.0000E-01
DA09	-1.7750E-01	DA12	9.8471E-02	DA13	6.0894E-02	DA14	-1.0015E-01	DA15	4.0683E-03	DA16	1.4250E-02
DA17	2.1146E-02	DA19	5.1563E-03	DA20	-3.6050E-02	DA21	-2.2500E-02	DA22	3.6665E-02	DA23	-5.0000E-03
DA24	4.5821E-01	DA25	4.5959E-01	DA26	4.6885E-01	DA28	4.6934E-01	DA32	-6.0000E-02	DA33	-5.0500E-01
DA34	-4.5000E-01	DA35	-6.2500E-01	DA37	4.5000E-02	DA38	3.0000E-02	DA39	3.5000E-02	DA40	5.0000E-02
A000	-1.0000E-01	A001	1.0000E-01	A002	3.8300E-02	A004	-3.8300E-02	A005	-1.5000E-01	A006	2.4112E-01
A007	1.8660E-01	A008	-3.8383E-01	A010	-2.0000E-01	A011	1.5000E-01	A012	8.0000E-02	A014	1.5000E-01
A015	-5.5000E-01	A016	-2.6429E-01	A017	7.5800E-02	A018	2.6381E-01	A019	2.6429E-01	A020	2.3530E-01
A021	2.1794E-01	A022	1.3349E-01	A023	-7.5151E-03	A024	-2.1794E-01	A026	2.9498E-01	A028	4.6042E-03
A029	-2.9498E-01	A030	5.6036E-01	A031	-2.7990E-02	A035	1.0138E-01	A036	-2.2795E-02	A041	6.7794E-01
A045	-9.2045E-03	A046	2.9861E-01	A049	-5.6668E-01	A051	-1.9348E-01	A052	-8.0000E-02	A053	2.3539E-01
A054	1.9348E-01	A055	-2.4423E-01	A056	1.7486E-01	A059	-6.2517E-01	A060	4.1920E-01	A062	4.0740E-03
A063	-2.7290E-01	A065	-1.4830E-01	A066	-5.5149E-02	A068	4.9921E-01	A071	4.2000E-03	A073	-3.4694E-01
A076	1.9989E-01	A078	2.4399E-01	A081	3.1711E-01	A083	-2.4077E-01	A084	-5.4666E-01	A086	-2.9839E-01
A088	4.2489E-01	A089	-6.1266E-01	A090	-5.7450E-03	A091	-2.5186E-02	A092	3.0612E-01	A093	-3.4145E-01
A096	-9.5844E-01	A100	-4.3060E-01	A101	2.3233E-01	A103	-3.8235E-01	A105	-4.3060E-01	A106	-7.5824E-01
A108	2.6918E-01	A110	-4.3057E-01	A111	5.2085E-01	A113	-7.3441E-02	A115	-4.3057E-01	A116	-1.7328E-01
A118	1.1747E-01	D000	3.5041E-01	D002	-2.5000E-02	D005	-1.7157E 00	D007	-3.7500E-02	D010	-4.0517E-01
D012	-5.0000E-02	D015	-1.4048E 00	D017	-5.5000E-02	D100	4.3716E-01	D105	1.0480E 00	D110	4.9973E-01
D115	3.3373E-01	T040	1.0000E-01	T041	1.5000E-01	T043	1.0138E-01	T048	1.4250E-02	T049	-1.1794E-02
T050	-1.3206E-02	T053	2.9861E-01	T80	-1.4400E-01	T82	-3.4560E-01	T83	-1.9590E-01	T88	-1.7230E-01
ZZ0003	0.0	ZZ0004	0.0	DUMMY	0.0						

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          *** DSL/91  SIMULATION DATA ***                                    76.167        20:12:24.46
     PARAM AXLE= 2
     END

***DSL MESSAGE 20***    NO OUTPUT REQUESTED...WARNING ONLY.

DSL/91  SIMULATION TIME=   0.0  SECONDS.                                     76.167        20:12:24.49

 DEBUG OUTPUT, 8LOCK   3 AT TIME=  0.2000E-02
```

TIME	2.0000E-03	DELT	1.0000E-03	DFLMIN	0.0	DELMAX	7.2370E 75	TSTART	0.0	FINTIM	2.0000E-03
CLKTIM	0.0	NALARM	0.0	DELS	0.0	DELNIX	7.2370E 75	DELADC	7.2370E 75	DELDAC	7.2370E 75
DELSTP	7.2370E 75	DELMRK	7.2370E 75	DFW2DT	3.7000E 01	DFW2	1.5000E-01	YCRDT	8.0000E 01	YCR	2.5500E 00
RPS1	4.3060E 01	RPS2	4.3060E 01	RPS3	4.3057E 01	XPS2DT	1.0000E 04	RPS4	4.3057E 01	XPS4DT	1.0000E 04
DFW1DT	3.0000E 01	DFW1	3.5000E-01	PSI1	2.1400E-01	PSI2	2.0400E-01	PSI3	1.6670E-02	PSI4	-1.5000E-02
ZO	-2.3400E 01	THEO	2.0900E-03	PHIO	3.0000E-03	RDTO	-5.0000E 02	U01	1.2000E-01	U02	1.0100E 00
U03	9.0000E-01	U04	1.2500E 00	U11	-6.1330E-01	U12	1.1100E 00	U13	1.6210E 00	U14	1.7000E 00
AM11	5.2500E 00	AM12	-7.4000E 00	AM13	-7.5000E 00	AM14	-8.3000E 00	TQFBR	8.0000E 03	TQR8R	7.1000E 03
MT1	-1.6430E 02	MT2	1.6430E 02	PDTO	-1.2000E-01	QDTO	9.0000E-02	UO	7.0400E 02	VO	1.3000E-01
WO	5.0000E-03	PO	2.0000E-02	QO	-3.7000E-02	RO	1.1000E-02	F1	9.0000E-01	F2	8.0000E-01
F3	-3.0000E-01	F4	6.0000E-01	G81	2.0000E-01	G82	4.0000E-01	G83	5.0000E-01	G84	8.5000E-01
AMS	5.1620E 00	AMUF	3.5900E-01	AMUR	5.7400E-01	TS	3.5860E 01	AIR	8.0000E 02	RF	8.1000E 04
TF	5.4300E 01	RR	5.0000E 04	RW	1.2850E 01	AIFW	5.8150E 00	AH1	2.0000E 02	AH2	2.0000E 02
AKT1	8.1200E 02	AKT2	8.1200E 02	AKT3	1.1920E 03	AKT4	1.1920E 03	AMCR	8.0000E-02	CFCR	2.0000E 02
CCR	1.1000E 01	AP	6.0600E 00	AA1	5.5300E 00	AA2	5.5300E 00	ANG	1.7500E 01	AKSC	6.1000E 02
ESP	-6.0000E-01	AKSL1	1.1700E 05	AKSL2	1.1700E 05	EP1	-2.0000E-02	EP2	-1.0000E-02	AIWF	7.3777E 00
AID	3.0000E-01	AR8R	4.1250E 00	AIWR	7.3777E 00	CFP	2.5000E 01	CRP	4.5000E 01	TR	5.3300E 01
AKF1	1.5000E 02	AKF2	1.5000E 02	AKR3	2.0000E 02	AKR4	2.0000E 02	A	5.6300E 01	8	3.9000E 01
G	3.8640E 02	ZF	1.0800E 01	ZR	1.0600E 01	AMU1	1.7950E-01	AMU2	1.7950E-01	AMU3	2.8700E-01
HRC	4.7000E 00	CRRC	1.1000E-02	TANP	0.0	DELSWO	1.4250E 00	L81	1.6500E 00	L82	1.6500E 00
L83	1.0000E 00	L84	1.0000E 00	AIDF	7.0000E-01	ARF8R	2.7000E 00	AIF	4.9800E 02	TSF	3.2250E 01
AMU4	2.8700E-01	FOTM	2.5000E 02	ROTM	4.0000E 02	HFC	7.2000E 00	SCALF	1.0000E 03	RWSF	2.0000E 01
AXLE	2.0000E 00	IDULTR	0.0	IDRSW	0.0	8ETA	2.5000E-01	ZZ0001	0.0	F1F1	2.5000E 01
F1F2	2.5000E 01	F1R3	4.5000E 01	F1R4	4.5000E 01	ANTI1	4.5000E 02	ANTI2	3.0000E 02	ANTI3	3.5000E 02
ANTI4	5.0000E 02	AUXRL1	4.0740E 01	AUXRL2	-4.0740E 01	Z1P	2.1378E-01	Z2P	5.0883E-02	Z3P	2.1147E-01
Z4P	5.1577E-02	FR1	4.8459E 02	ZZ0002	0.0	FR2	1.5565E 03	FR3	5.5008E 02	FR4	2.4028E 02
FXU1	2.1540E 01	FXU2	-1.6027E 03	FXU3	-5.8931E 02	FXU4	-3.2377E 02	FYU1	1.9030E 01	FYU2	-2.4560E 02
FYU3	-3.5178E 01	FYU4	3.9317E 01	NPHIF	6.8758E 04	NPHIR	-9.6117E 03	TP	-6.0195E 04	AMSS1	-1.1831E 04
AMSS2	-3.5816E 04	DFW1DD	1.4745E 03	DFW2DD	5.4149E 03	YCRDD	-2.4537E 05	SFSF	1.0000E-01	U1	7.0330E 02
U2	7.0390E 02	U3	7.0331E 02	U4	7.0390E 02	DEL1	3.8300E-01	DEL1DT	1.0000E 01	DEL1DD	1.3036E 03
DEL2	1.8660E 00	DEL2DT	1.5000E 01	DEL2DD	-6.9607E 03	ZET1	3.8300E-01	ZET2	1.8660E 00	ZET1DT	1.0000E 01
ZET2DT	1.5000E 01	F2F1	5.7450E 01	F2F2	2.7990E 02	F3F1	1.4400E 02	F3F2	1.7230E 02	F4F1	-3.7674E 01
F4F2	3.7674E 01	S1P	2.6429E 02	S2P	-2.1794E 02	Z1	-1.2253E 01	Z2	-1.0933E 01	V1	2.8824E-01
V2	3.1464E-01	W1	-7.3689E 00	W2	1.6545E 01	A005A	-1.5000E-01	A007A	1.8660E-01	A014A	1.5000E-01
D005D	-1.7402E 00	D007D	-3.7500E-02	DEL3	2.5000E-01	DEL3DT	6.9000E 01	DEL3DD	-9.2161E 02	DEL4	1.5000E-01
DEL4DT	7.0000E 01	DEL4DD	7.5058E 02	ZET3	2.5000E-01	ZET4	1.5000E-01	ZET3DT	6.9000E 01	ZET4DT	7.0000E 01
F2R3	5.0000E 01	F2R4	3.0000E 01	F3R4	6.4500E 02	F3R3	6.4270E 02	S3P	-3.8946E 02	S4P	-2.1824E 02
Z3	-1.2389E 01	Z4	-1.2648E 01	V3	-7.5877E-01	V4	-7.6397E-01	W3	7.0981E 01	W4	6.8029E 01
A015A	-7.0000E-01	A017A	1.5000E-02	D017D	-1.7500E-01	D015D	1.8765E-01	SMP	-5.6135E 02	S1	6.7242E 02
S2	1.9019E 02	S3	1.9971E 02	S4	3.7093E 02	UG1	7.0329E 02	UG2	7.0393E 02	UG3	7.0346E 02
UG4	7.0404E 02	VG1	3.1034E-01	VG2	2.6500E-01	VG3	-9.7171E-01	VG4	-9.6805E-01	UG1P	6.8731E 02
UG2P	6.8939E 02	UG3P	7.0345E 02	UG4P	7.0406E 02	XI1	2.3233E-01	XI2	3.1711E-01	XI3	2.4172E-01
XI4	2.2648E-01	SLIP1	2.3233E-01	SLIP2	3.1711E-01	SLIP3	2.4172E-01	SLIP4	2.2648E-01	AM21	-7.3330E-01
AM22	1.0000E-01	AM23	7.2100E-01	AM24	4.5000E-01	SI1	2.0056E-02	SI2	-1.3467E-01	SI3	-1.0948E-01
SI4	-1.4286E-01	U1P	-5.0371E-02	U2P	1.0417E 00	U3P	1.0743E 00	U4P	1.3519E 00	FC1	2.4409E 01
FC2	-1.6214E 03	FC3	-5.9093E 02	FC4	-3.2484E 02	AIFBR	8.3227E 00	AIF8RP	9.4500E-01	AI8R	8.6539E 00
AI8RP	1.2762E 00	RPS1DT	1.7486E 03	RPS2DT	4.1920E 03	RPS3DT	1.9172E 02	RPS4DT	1.2669E 03	TIN	1.0000E-04
DAC00	-4.7175E 02	DAC01	2.1378E-01	DAC02	-5.2825E 02	DAC03	5.0883E-02	DAC08	-8.0000E 03	DAC09	-7.1000E 03
DAC16	1.4250E-01	DAC17	2.1146E-01	DAC19	5.1563E-02	DAC20	7.2100E-01	DAC21	4.5000E-01	DAC22	-7.3330E-01
DAC23	1.0000E-01	DAC24	6.8731E 02	DAC25	6.8939E 02	DAC26	7.0345E 02	DAC28	7.0406E 02	DAC32	1.2000E-01

DAC33	1.0100E 00	DAC34	9.0000E-01	DAC35	1.2500E 00	DAC37	4.5000E 02	DAC38	3.0000E 02	DAC39	3.5000E 02
DAC40	5.0000E 02	DAC04	0.0	DAC05	2.6396E 03	DAC06	0.0	DAC07	3.0335E 03	DAC12	0.0
DAC13	2.4608E 03	DAC14	0.0	DAC15	2.4570E 03	DA00	-1.1794E-02	DA01	2.1378E-02	DA02	-1.3206E-02
DA03	5.0883E-03	DA04	0.0	DA05	6.5991E-02	DA06	0.0	DA07	7.5838E-02	DA08	-2.0000E-01
DA09	-1.7750E-01	DA12	0.0	DA13	6.1520E-02	DA14	0.0	DA15	6.1424E-02	DA16	1.4250E-02
DA17	2.1146E-02	DA19	5.1563E-03	DA20	-3.6050E-02	DA21	-2.2500E-02	DA22	3.6665E-02	DA23	-5.0000E-03
DA24	4.5821E-01	DA25	4.5959E-01	DA26	4.6896E-01	DA28	4.6937E-01	DA32	-6.0000E-02	DA33	-5.0500E-01
DA34	-4.5000E-01	DA35	-6.2500E-01	DA37	4.5000E-02	DA38	3.0000E-02	DA39	3.5000E-02	DA40	5.0000E-02
A000	-1.0000E-01	A001	1.0000E-01	A002	3.8300E-02	A004	-3.8300E-02	A005	-1.5000E-01	A006	2.4112E-01
A007	1.8660E-01	A008	-3.8383E-01	A010	-6.9000E-01	A011	1.5000E-01	A012	2.5000E-02	A014	1.5000E-01
A015	-7.0000E-01	A016	-2.6429E-01	A017	1.5000E-02	A018	2.6381E-01	A019	2.6429E-01	A020	2.2648E-01
A021	2.1794E-01	A022	1.2669E-01	A023	-7.5151E-03	A024	-2.1794E-01	A026	3.8946E-01	A028	4.6042E-03
A029	-3.8946E-01	A030	5.3714E-01	A031	-2.7990E-02	A035	7.0000E-01	A036	-5.0000E-03	A041	6.7596E-01
A045	-3.0000E-03	A046	6.9000E-01	A049	-6.1943E-01	A051	2.1824E-01	A052	-2.5000E-02	A053	2.3539E-01
A054	-2.1824E-01	A055	-8.5610E-02	A056	1.7486E-01	A059	-6.3242E-01	A060	4.1920E-01	A062	4.0740E-03
A063	-2.7290E-01	A065	-1.4830E-01	A066	-5.6135E-01	A068	4.9921E-01	A071	1.0000E-02	A073	-3.7914E-01
A076	1.9172E-02	A078	2.6671E-01	A081	3.1711E-01	A083	-7.6770E-02	A084	-5.4666E-01	A086	-2.9839E-01
A088	1.2394E-01	A089	-6.1266E-01	A090	-5.7450E-03	A091	-2.5186E-02	A092	2.4172E-01	A093	-3.4145E-01
A096	-9.5844E-01	A100	-4.3060E-01	A101	2.3233E-01	A103	-3.8676E-01	A105	-4.3060E-01	A106	-2.3074E-01
A108	2.7230E-01	A110	-4.3057E-01	A111	5.2085E-01	A113	-4.3086E-02	A115	-4.3057E-01	A116	-1.0079E-01
A118	6.8129E-02	D000	3.2590E-01	D002	-2.5000E-02	D005	-1.7402E 00	D007	-3.7500E-02	D010	-2.3040E-01
D012	-1.7250E-01	D015	1.8765E-01	D017	-1.7500E-01	D100	4.3716E-01	D105	1.0480E 00	D110	4.7929E-02
D115	3.1674E-01	T040	1.0000E-01	T041	1.5000E-01	T043	7.0000E-01	T048	1.4250E-02	T049	-1.1794E-02
T050	-1.3206E-02	T053	6.9000E-01	T80	-1.4400E-01	T82	-6.4270E-01	T83	-6.4500E-01	T88	-1.7230E-01
ZZ0003	0.0	ZZ0004	0.0	DUMMY	0.0						

```
          *** DSL/91  SIMULATION DATA ***                                                 76.170        13:28:03.02
 TITLE === PROB 52 VEHICLE SIMULATION ===
 INCON  DFW2DT=37.    ,DFW2  =0.15  ,YCRDT =80.    ,YCR   =2.55
 INCON  RPS1  =43.06  ,RPS2  =43.06  ,RPS3  =43.057,XPS2DT=10000.
 INCON  RPS4  =43.057,XPS4DT=10000.,DFW1DT=30.    ,DFW1  =0.35
 INCON  PSI1  =.2140  ,PSI2  =.2040  ,PSI3  =.01667,PSI4  =-.0150
 INCON  ZC    =-23.4  ,THED  =.00209,PHIC  =.00300,RDTC  =-500.0
 INCON  U01   =.120   ,U02   =1.01   ,U03   =.900  ,U04   =1.250
 INCON  U11   =-.6133,U12   =1.11   ,U13   =1.621 ,U14   =1.700
 INCON  AM11  =5.25   ,AM12  =-7.40  ,AM13  =-7.50 ,AM14  =-8.30
 INCON  TQFBR =8000.  ,TQRBR =7100.  ,MT1   =-164.3,MT2   =164.3
 INCON  PCTO  =-.12   ,QCTO  =.0900  ,UC    =704.  ,VO    =.1300
 INCON  WC    =.0050  ,PC    =.0200  ,QC    =-.0370,RO    =.0110
 INCON  F1    =.9     ,F2    =.8     ,F3    =-.3   ,F4    =.6
 INCON  GB1   =.2     ,GB2   =.4     ,GB3   =.5    ,GB4   =.85
 PARAM  AMS   =5.162  ,AMUF  =0.359  ,AMUR  =0.574 ,TS    = 35.86
 PARAM  AIR   =800.   ,RF    =81E03  ,TF    =54.3  ,RR    =50E03
 PARAM  RW    =12.85  ,AIFW  =5.815  ,AH1   =200.  ,AH2   =200.
 PARAM  AKT1  =812.   ,AKT2  =812.   ,AKT3  =1192. ,AKT4  =1192.
 PARAM  AMCR  =0.08   ,CFCR  =200.   ,CCR   =11.   ,AP    =6.06
 PARAM  AA1   =5.53   ,AA2   =5.53   ,ANG   =17.5  ,AKSC  =610.
 PARAM  ESP   =-.6    ,AKSL1 =1.17E5,AKSL2 =1.17E5,FP1   =-.0200
 PARAM  FP2   =-.01   ,AIWF  =7.3777,AIC   =0.3   ,ARBR  =4.125
 PARAM  AIWR  =7.3777,CFP   =25.    ,CPP   =45.   ,TR    =53.3
 PARAM  AKF1  =150.   ,AKF2  =150.   ,AKR3  =200.  ,AKR4  =200.
 PARAM  A     =56.3   ,B     =39.0   ,G     =386.4 ,ZF    =10.8
 PARAM  ZR    =10.6   ,AMU1  =.1795  ,AMU2  =.1795 ,AMU3  =.2870
 PARAM  HRC   =4.70   ,CPRC  =0.0110,TANP  =0.0   ,DELSWC=1.425
 PARAM  LB1   =1.65   ,LB2   =1.65   ,LB3   =1.0   ,LB4   =1.0
 PARAM  AICF  = .7    ,ARFBR = 2.7   ,AIF   = 498. ,TSF   = 32.25
 PARAM  AMU4  =.2870  ,FCTM  = 250.  ,RCTM  = 400. ,HFC   =7.20
 PARAM SCALE = 1000. ,RWSF  =20.
 PARAM   AXLE= 0
 PARAM   ICLLTR= 0
 PARAM   ICRSW= 0
 PARAM  BETA  =0.25
 CONTRL TSTART=0.0,FINTIM=.002,DELT=.001
 END

***DSL MESSAGE 20***   NO OUTPUT REQUESTED...WARNING ONLY.

DSL/91  SIMULATION TIME=   0.0  SECONDS.                                                  76.170        13:28:04.23

 DEBUG OUTPUT, BLOCK   3 AT TIME=  0.2000E-02

 TIME      2.0000E-03  DELT      1.0000E-03  DELMIN    0.0         DELMAX    7.2370E 75  TSTART    0.0         FINTIM    2.0000E-03
 CLKTIM    0.0         NALARM    0.0         DELS      0.0         DELNIX    7.2370E 75  DELADC    7.2370E 75  DELDAC    7.2370E 75
 DELSTP    7.2370E 75  DELMRK    7.2370E 75  DFW2DT    3.7000E 01  DFW2      1.5000E-01  YCRDT     8.0000E 01  YCR       2.5500E 00
 RPS1      4.3060E 01  RPS2      4.3060E 01  RPS3      4.3057E 01  XPS2DT    1.0000E 04  RPS4      4.3057E 01  XPS4DT    1.0000E 04
 DFW1DT    3.0000E 01  DFW1      3.5000E-01  PSI1      2.1400E-01  PSI2      2.0400E-01  PSI3      1.6670E-02  PSI4     -1.5000E-02
 ZC       -2.3400E 01  THEC      2.0900E-03  PHIO      3.0000E-03  RDTO     -5.0000E 02  U01       1.2000E-01  U02       1.0100E 00
 U03       9.0000E-01  U04       1.2500E 00  U11      -6.1330E-01  U12       1.1100E 00  U13       1.6210E 00  U14       1.7000E 00
 AM11      5.2500E 00  AM12     -7.4000E 00  AM13     -7.5000E 00  AM14     -8.3000E 00  TQFBR     8.0000E 03  TQRBR     7.1000E 03
 MT1      -1.6430E 02  MT2       1.6430E 02  PCTO     -1.2000E-01  QCTO      9.0000E-02  UO        7.0400E 02  VO        1.3000E-01
 WC        5.0000E-03  PO        2.0000E-02  QC       -3.7000E-02  RO        1.1000E-02  F1        9.0000E-01  F2        8.0000E-01
 F3       -3.0000E-01  F4        6.0000E-01  GB1       2.0000E-01  GB2       4.0000E-01  GB3       5.0000E-01  GB4       8.5000E-01
 AMS       5.1620E 00  AMUF      3.5900E-01  AMUR      5.7400E-01  TS        3.5860E 01  AIR       8.0000E 02  RF        8.1000E 04
 TF        5.4300E 01  RR        5.0000E 04  RW        1.2850E 01  AIFW      5.8150E 00  AH1       2.0000E 02  AH2       2.0000E 02
 AKT1      8.1200E 02  AKT2      8.1200E 02  AKT3      1.1920E 03  AKT4      1.1920E 03  AMCR      8.0000E-02  CFCR      2.0000E 02
 CCR       1.1000E 01  AP        6.0600E 00  AA1       5.5300E 00  AA2       5.5300E 00  ANG       1.7500E 01  AKSC      6.1000E 02
 ESP      -6.0000E-01  AKSL1     1.1700E 05  AKSL2     1.1700E 05  FP1      -2.0000E-02  FP2      -1.0000E-02  AIWF      7.3777E 00
```

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
AIC	3.0000E-01	ARBR	4.1250E 00	AIWR	7.3777E 00	CFP	2.5000E 01	CRP	4.5000E 01	TR	5.3300E 01
AKF1	1.5000E 02	AKF2	1.5000E 02	AKF3	2.0000E 02	AKR4	2.0000E 02	A	5.6300E 01	B	3.9000E 01
G	3.8640E 02	ZF	1.0800E 01	ZR	1.0600E 01	AMU1	1.7950E-01	AMU2	1.7950E-01	AMU3	2.8700E-01
HRC	4.7000E 00	CRRC	1.1000E-02	TANP	0.0	DELSWO	1.4250E 00	LB1	1.6500E 00	LB2	1.6500E 00
LB3	1.0000E 00	LB4	1.0000E 00	AICF	7.0000E-01	ARFBR	2.7000E 00	AIF	4.9800E 02	TSF	3.2250E 01
AMU4	2.8700E-01	FOTM	2.5000E 02	ROTM	4.0000E 02	HFC	7.2000E 00	SCALE	1.0000E 03	RWSF	2.0000E 01
AXLF	0.0	ICULTR	0.0	ICRSW	0.0	BETA	2.5000E-01	P014	0.0	P031	0.0
P033	0.0	P057	0.0	ZZ0001	0.0	F1F1	2.5000E 01	F1F2	-2.5000E 01	F1R3	4.5000E 01
F1R4	4.5000E 01	ANTI1	4.5000E 02	ANTI2	3.0000E 02	ANTI3	3.5000E 02	ANTI4	5.0000E 02	AUXRL1	-1.3324E 01
AUXRL2	1.3324E 01	Z1P	2.1378E-01	Z2P	5.0883E-02	Z3P	2.1147E-01	Z4P	5.1577E-02	FR1	9.1028E 02
ZZ0002	0.0	FR2	1.1663E 02	FR3	1.8077E 03	FR4	4.1310E 02	FXU1	6.0307E 01	FXU2	-1.1879E 02
FXU3	-2.0205E 03	FXU4	-5.5828E 02	FYU1	4.0060E 01	FYU2	-1.8134E 01	FYU3	-1.1700E 02	FYU4	6.7620E 01
NPHIF	-2.6313E 04	NPHIR	-4.4863E 04	TP	-6.0195E 04	AMSS1	-1.1831E 04	AMSS2	-3.5816E 04	DFW1DD	1.4745E 03
DFW2DD	5.4149E 03	YCRDD	-2.4537E 05	SFSF	1.0000E-01	U1	7.0330E 02	U2	7.0390E 02	U3	7.0331E 02
U4	7.0390E 02	DEL1	5.0000E-01	DEL1DT	5.0000E 00	DEL1DD	1.0947E 03	DEL2	1.5000E-02	DEL2DT	9.5000E-01
DEL2DD	-5.2564E 01	ZET1	7.4187E-01	ZET2	2.5813E-01	ZET1DT	2.0319E 01	ZET2DT	-1.0319E 01	F2F1	1.1128E 02
F2F2	3.8719E 01	F3F1	2.0150E 02	F3F2	-4.1100E 01	F4F1	-3.7674E 01	F4F2	3.7674E 01	S1P	7.4545E 01
S2P	3.6506E 02	Z1	-1.1729E 01	Z2	-1.2706E 01	V1	-1.0609E 01	V2	-1.1792E 01	W1	3.3424E 01
W2	-1.9247E 01	A005A	-9.5000E-01	A007A	6.0000E-02	A014A	9.5000E-01	D005D	-1.3141E 03	D007D	-9.5000E-02
DEL3	8.0000E-01	DEL3DT	2.0000E 01	DEL3DD	-1.5445E 03	DEL4	1.8950E-02	DEL4DT	5.5000E-01	DEL4DD	-5.6191E 01
ZET3	1.1398E 00	ZET4	4.6023E-01	ZET3DT	2.9861E 01	ZET4DT	1.0139E 01	F2R3	2.2795E 02	F2R4	9.2045E 01
F3R4	1.9590E 02	F3R3	3.4560E 02	S3P	-2.9498E 02	S4P	1.9348E 02	Z3	-1.1334E 01	Z4	-1.2503E 01
V3	-6.9711E 00	V4	-7.1378E 00	W3	3.6638E 01	W4	3.3715E 00	A015A	-5.5000E-01	A017A	7.5800E-02
D017D	-5.5000E-02	D015D	-1.4048E 00	SMP	3.3810E 02	S1	4.8267E 02	S2	7.7318E 02	S3	2.9419E 02
S4	7.8265E 02	UG1	7.0337E 02	UG2	7.0386E 02	UG3	7.0339E 02	UG4	7.0391E 02	VG1	-1.0709E 01
VG2	-1.1734E 01	VG3	-7.0810E 00	VG4	-7.1479E 00	UG1P	6.9505E 02	UG2P	6.8683E 02	UG3P	7.0327E 02
UG4P	7.0401E 02	XI1	2.6276E-01	XI2	2.0345E-01	XI3	3.0612E-01	XI4	2.3530E-01	SLIP1	2.6276E-01
SLIP2	2.0345E-01	SLIP3	3.0612E-01	SLIP4	2.3530E-01	AM21	-7.3330E-01	AM22	1.0000E-01	AM23	7.2100E-01
AM24	4.5000E-01	SI1	2.0056E-02	SI2	-1.3467E-01	SI3	-1.0948E-01	SI4	-1.4286E-01	U1P	-7.2681E-02
U2P	1.0303E 00	U3P	1.1207E 00	U4P	1.3559E 00	FC1	6.6160E 01	FC2	-1.2017E 02	FC3	-2.0259E 03
FC4	-5.6011E 02	AIFBR	8.3227E 00	AIFBRP	9.4500E-01	AIBP	8.6539E 00	AIBRP	1.2762E 00	RPS1DT	1.6840E 03
RPS2DT	1.9961E 03	RPS3DT	1.9989E 03	RPS4DT	1.3349E 03	TIN	1.0000E-04	P000	5.0000E-02	P001	4.8431E-02
P016	2.5000E-02	P018	8.0000E-02	P019	5.0000E-03	P021	2.5000E-01	P022	2.5000E-02	P024	5.0000E-03
P027	4.5000E-02	P028	2.5000E-01	P029	9.0000E-03	P030	5.0000E-02	P043	2.0000E-01	P049	4.5000E-02
P050	1.4747E-01	P054	9.0000E-03	P055	6.6667E-01	P056	6.6667E-01	P058	6.6667E-01	P060	6.6667E-01
P061	6.6667E-01	P062	5.0000E-01	P063	5.0000E-01	P064	1.0000E-01	P065	1.0000E-01	P068	1.0000E-01
P069	1.0000E-01	P072	6.6667E-01	P073	2.5000E-01	P083	1.1019E-01	P085	2.5000E-01	P086	2.0000E-01
P087	1.0000E-01	P088	6.4250E-01	P096	2.0000E-01	P098	6.4250E-01	P099	1.0000E-01	P100	2.5000E-01
P101	4.3060E-01	P104	4.3060E-01	P105	2.5000E-01	P106	2.0000E-01	P107	1.0000E-01	P108	6.4250E-01
P110	4.3057E-01	P111	4.6222E-01	P112	4.6222E-01	P113	1.1019E-01	P114	4.3057E-01	P116	2.0000E-01
P117	1.0000E-01	P118	6.4250E-01	P119	1.4747E-01	P002	6.9638E-02	P003	6.7875E-01	P008	1.6190E-01
P025	1.0000E-01	P032	1.1309E-01	P034	6.9638E-02	P037	9.5000E-01	P038	6.0000E-02	P039	6.2791E-02
P044	6.2791E-02	P047	1.6125E-01	P059	1.6125E-01	P066	4.0312E-01	P067	4.0312E-01	P095	1.1309E-01
P097	6.7875E-01	P004	0.0	P005	0.0	P006	0.0	P007	0.0	P009	4.3554E-02
P010	1.0383E-01	P011	1.0383E-01	P012	4.8431E-02	P013	4.3554E-02	P015	1.1206E-01	P017	1.0000E-01
P020	7.5800E-02	P023	5.5000E-01	P026	3.4858E-02	P035	1.7930E-01	P036	4.4825E-01	P045	4.4825E-01
P046	1.7930E-01	P053	3.4858E-02	P071	0.0	P109	6.6625E-01	P115	6.6625E-01	P080	0.0
P081	0.0	P082	0.0	P051	8.8049E-02	P052	8.9459E-01	P090	0.0	P091	0.0
P102	8.8049E-02	P103	8.9459E-01	P000P	5.0000E-02	P001P	4.8431E-02	P002P	6.9638E-02	P003P	6.7875E-01
P004P	0.0	P005P	0.0	P006P	0.0	P007P	0.0	P008P	1.6190E-01	P009P	4.3554E-02
P010P	1.0383E-01	P011P	1.0383E-01	P012P	4.8431E-02	P013P	4.3554E-02	P014P	0.0	P015P	1.1206E-01
P016P	2.5000E-02	P017P	1.0000E-01	P018P	8.0000E-02	P019P	5.0000E-03	P020P	7.5800E-02	P021P	2.5000E-01
P022P	2.5000E-02	P023P	5.5000E-01	P024P	5.0000E-03	P025P	1.0000E-01	P026P	3.4858E-02	P027P	4.5000E-02
P028P	2.5000E-01	P029P	9.0000E-03	P030P	5.0000E-02	P031P	0.0	P032P	1.1309E-01	P033P	0.0
P034P	6.9638E-02	P035P	1.7930E-01	P036P	4.4825E-01	P037P	9.5000E-01	P038P	6.0000E-02	P039P	6.2791E-02
P043P	2.0000E-01	P044P	6.2791E-02	P045P	4.4825E-01	P046P	1.7930E-01	P047P	1.6125E-01	P049P	4.5000E-02
P050P	1.4747E-01	P051P	8.8049E-02	P052P	8.9459E-01	P053P	3.4858E-02	P054P	9.0000E-03	P055P	6.6667E-01
P056P	6.6667E-01	P057P	0.0	P058P	6.6667E-01	P059P	1.6125E-01	P060P	6.6667E-01	P061P	6.6667E-01
P062P	5.0000E-01	P063P	5.0000E-01	P064P	1.0000E-01	P065P	1.0000E-01	P066P	4.0312E-01	P067P	4.0312E-01
P068P	1.0000E-01	P069P	1.0000E-01	P071P	0.0	P072P	6.6667E-01	P073P	2.5000E-01	P080P	0.0
P081P	0.0	P082P	0.0	P083P	1.1019E-01	P086P	2.0000E-01	P087P	1.0000E-01	P088P	6.4250E-01
P090P	0.0	P091P	0.0	P095P	1.1309E-01	P096P	2.0000E-01	P097P	6.7875E-01	P098P	6.4250E-01
P099P	1.0000E-01	P101P	4.3060E-01	P102P	8.8049E-02	P103P	8.9459E-01	P104P	4.3060E-01	P105P	2.5000E-01
P106P	2.0000E-01	P107P	1.0000E-01	P108P	6.4250E-01	P109P	6.6625E-01	P110P	4.3057E-01	P111P	4.6222E-01
P112P	4.6222E-01	P113P	1.1019E-01	P114P	4.3057E-01	P115P	6.6625E-01	P116P	2.0000E-01	P117P	1.0000E-01
P118P	6.4250E-01	P119P	1.4747E-01	ZZ0003	0.0	ZZ0004	0.0	DUMMY	0.0		

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             *** DSL/91  SIMULATION DATA ***                                              76.170      13:28:10.06
        PARAM  AXLE  =1
        END

 ***DSL MESSAGE 20***    NO OUTPUT REQUESTED...WARNING ONLY.

 DSL/91  SIMULATION TIME=   0.0  SECONDS.                                                 76.170      13:28:10.08

  DEBUG OUTPUT, BLOCK   3 AT TIME=  0.2000E-02

  TIME     2.0000E-03  DELT     1.0000E-03  DELMIN   0.0         DELMAX   7.2370E 75  TSTART   0.0         FINTIM   2.0000E-03
  CLKTIM   0.0         NALARM   0.0         DELS     0.0         DELNIX   7.2370E 75  DELADC   7.2370E 75  DELDAC   7.2370E 75
  DELSTP   7.2370E 75  DELMRK   7.2370E 75  DFW2DT   3.7000E 01  DFW2     1.5000E-01  YCRDT    8.0000E 01  YCR      2.5500E 00
  RPS1     4.3060E 01  RPS2     4.3060E 01  RPS3     4.3057E 01  XPS2DT   1.0000E 04  RPS4     4.3057E 01  XPS4DT   1.0000E 04
  DFW1DT   3.0000E 01  DFW1     3.5000E-01  PSI1     2.1400E-01  PSI2     2.0400E-01  PSI3     1.6670E-02  PSI4    -1.5000E-02
  ZC      -2.3400E 01  THEC     2.0900E-03  PHIC     3.0000E-03  RDTO    -5.0000E 02  U01      1.2000E-01  U02      1.0100E 00
  U03      9.0000E-01  U04      1.2500E 00  U11     -6.1330E-01  U12      1.1100E 00  U13      1.6210E 00  U14      1.7000E 00
  AM11     5.2500E 00  AM12    -7.4000E 00  AM13    -7.5000E 00  AM14    -8.3000E 00  TQFBR    8.0000E 03  TQRBR    7.1000E 03
  MT1     -1.6430E 02  MT2      1.6430E 02  PDTO    -1.2000E-01  QDTO     9.0000E-02  U0       7.0400E 02  V0       1.3000E-01
  WC       5.0000E-03  P0       2.0000E-02  Q0      -3.7000E-02  R0       1.1000E-02  F1       9.0000E-01  F2       8.0000E-01
  F3      -3.0000E-01  F4       6.0000E-01  GB1      2.0000E-01  GB2      4.0000E-01  GB3      5.0000E-01  GB4      8.5000E-01
  AMS      5.1620E 00  AMUF     3.5900E-01  AMUR     5.7400E-01  TS       3.5860E 01  AIR      8.0000E 02  RF       8.1000E 04
  TF       5.4300E 01  RR       5.0000E 04  RW       1.2850E 01  AIFW     5.8150E 00  AH1      2.0000E 02  AH2      2.0000E 02
  AKT1     8.1200E 02  AKT2     8.1200E 02  AKT3     1.1920E 03  AKT4     1.1920E 03  AMCP     8.0000E-02  CFCR     2.0000E 02
  CCR      1.1000E 01  AP       6.0600E 00  AA1      5.5300E 00  AA2      5.5300E 00  ANG      1.7500E 01  AKSC     6.1000E 02
  ESP     -6.0000E-01  AKSL1    1.1700E 05  AKSL2    1.1700E 05  EP1     -2.0000E-02  EP2     -1.0000E-02  AIWF     7.3777E 00
  AIC      3.0000E-01  ARBR     4.1250E 00  AIWR     7.3777E 00  CFP      2.5000E 01  CRP      4.5000E 01  TR       5.3300E 01
  AKF1     1.5000E 02  AKF2     1.5000E 02  AKR3     2.0000E 02  AKR4     2.0000E 02  A        5.6300E 01  B        3.9000E 01
  G        3.8640E 02  ZF       1.0800E 01  ZR       1.0600E 01  AMUL     1.7950E-01  AMU2     1.7950E-01  AMU3     2.8700E-01
  HRC      4.7000E 00  CRRC     1.1000E-02  TANP     0.0         DELSWD   1.4250E 00  LB1      1.6500E 00  LB2      1.6500E 00
  LB3      1.0000E 00  LB4      1.0000E 00  AIDF     7.0000E-01  ARFBR    2.7000E 00  AIF      4.9800E 02  TSF      3.2250E 01
  AMU4     2.8700E-01  FOTM     2.5000E 02  RCTM     4.0000E 02  HFC      7.2000E 00  SCALE    1.0000E 03  RWSF     2.0000E 01
  AXLE     1.0000E 00  IDULTR   0.0         IDRSW    0.0         BETA     2.5000E-01  P014     0.0         P031     0.0
  P033     0.0         P057     0.0         ZZ0001   0.0         F1F1     2.5000E 01  F1F2     2.5000E 01  F1R3     4.5000E 01
  F1R4     4.5000E 01  ANTI1    4.5000E 02  ANTI2    3.0000E 02  ANTI3    3.5000E 02  ANTI4    5.0000E 02  AUXRL1   4.0740E 01
  AUXRL2  -4.0740E 01  Z1P      2.1378E-01  Z2P      5.0883E-02  Z3P      2.1147E-01  Z4P      5.1577E-02  FR1      4.8459E 02
  ZZ0002   0.0         FR2      1.5565E 03  FR3      1.8077E 03  FR4      4.1310E 02  FXU1     2.1540E 01  FXU2    -1.6027E 03
  FXU3    -2.0205E 03  FXU4    -5.5828E 02  FYU1     1.9030E 01  FYU2    -2.4560E 02  FYU3    -1.1700E 02  FYU4     6.7620E 01
  NPHIF    6.8758E 04  NPHIR   -4.4863E 04  TP      -6.0195E 04  AMSS1   -1.1831E 04  AMSS2   -3.5816E 04  DFW1DD   1.4745E 03
  DFW2DD   5.4149E 03  YCRDD   -2.4537E 05  SFSF     1.0000E-01  U1       7.0330E 02  U2       7.0390E 02  U3       7.0331E 02
  U4       7.0390E 02  DEL1     3.8300E-01  DEL1DT   1.0000E 01  DEL1DD   1.4017E 03  DEL2     1.8660E 00  DEL2DT   1.5000E 01
  DEL2DD  -6.8627E 03  ZET1     3.8300E-01  ZET2     1.8660E 00  ZET1DT   1.0000E 01  ZET2DT   1.5000E 01  E2F1     5.7450E 01
  F2F2     2.7990E 02  F3F1     1.4400E 02  F3F2     1.7230E 02  F4E1    -3.7674E 01  F4F2     3.7674E 01  S1P      2.6429E 02
  S2P     -2.1794E 02  Z1      -1.2253E 01  Z2      -1.0933E 01  V1       2.8824E-01  V2       3.1464E-01  W1      -7.3689E 00
  W2       1.6545E 01  A005A   -1.5000E-01  A007A    1.8660E-01  A014A    1.5000E-01  D005D   -1.7157E 00  D007D   -3.7500E-02
  DEL3     8.0000E-01  DEL3DT   2.0000E 01  DEL3DD  -1.6207E 03  DEL4     1.8950E-02  DEL4DT   5.5000E-01  DEL4DD  -5.6191E 01
  ZET3     1.1398E 00  ZET4     4.6023E-01  ZET3DT   2.9861E 01  ZET4DT   1.0139E 01  F2R3     2.2795E 02  F2R4     9.2045E 01
  F3R4     1.9590E 02  F3R3     3.4560E 02  S3P     -2.9498E 02  S4P      1.9348E 02  Z3      -1.1334E 01  Z4      -1.2503E 01
  V3      -6.9711E 00  V4      -7.1378E 00  W3       3.6638E 01  W4       3.3715E 00  A015A   -5.5000E-01  A017A    7.5800E-02
  D017D   -5.5000E-02  D015D   -1.4048E 00  SMP     -5.5149E 01  S1       6.7242E 02  S2       1.9019E 02  S3       2.9419E 02
  S4       7.8265E 02  UG1      7.0329E 02  UG2      7.0393E 02  UG3      7.0339E 02  UG4      7.0391E 02  VG1      3.1034E-01
  VG2      2.6500E-01  VG3     -7.0810E 00  VG4     -7.1479E 00  UG1P     6.8731E 02  UG2P     6.8939E 02  UG3P     7.0327E 02
  UG4P     7.0401E 02  XI1      2.3233E-01  XI2      3.1711E-01  XI3      3.0612E-01  XI4      2.3530E-01  SLIP1    2.3233E-01
  SLIP2    3.1711E-01  SLIP3    3.0612E-01  SLIP4    2.3530E-01  AM21    -7.3330E-01  AM22     1.0000E-01  AM23     7.2100E-01
  AM24     4.5000E-01  SI1      2.0056E-02  SI2     -1.3467E-01  SI3     -1.0948E-01  SI4     -1.4285E-01  U1P     -5.0371E-02
  U2P      1.0417E 00  U3P      1.1207E 00  U4P      1.3559E 00  FC1      2.4409E 01  FC2     -1.6214E 03  FC3     -2.0259E 03
  FC4     -5.6011E 02  AIFBR    8.3227E 00  AIFBRP   9.4500E-01  AIBR     8.6539E 00  AIBRP    1.2762E 00  RPS1DT   1.7486E 03
  RPS2DT   4.1920E 03  RPS3DT   1.9989E 03  RPS4DT   1.3349E 03  TIN      1.0000E-04  P000     1.0000E-01  P001     4.8431E-02
  P016     2.5000E-02  P018     8.0000E-02  P019     5.0000E-03  P021     2.5000E-01  P022     2.5000E-02  P024     5.0000E-03
  P027     4.5000E-02  P028     2.5000E-01  P029     9.0000E-03  P030     3.8300E-02  P043     2.0000E-01  P049     4.5000E-02
  P050     1.4747E-01  P054     9.0000E-03  P055     6.6667E-01  P056     6.6667E-01  P058     6.6667E-01  P060     6.6667E-01
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P061	6.6667E-01	P062	5.0000E-01	P063	5.0000E-01	P064	1.0000E-01	P065	1.0000E-01	P068	1.0000E-01
P069	1.0000E-01	P072	6.6667E-01	P073	2.5000E-01	P083	1.1019E-01	P085	2.5000E-01	P086	2.0000E-01
P087	1.0000E-01	P088	6.4250E-01	P096	2.0000E-01	P098	6.4250E-01	P099	1.0000E-01	P100	2.5000E-01
P101	4.3060E-01	P104	4.3060E-01	P105	2.5000E-01	P106	2.0000E-01	P107	1.0000E-01	P108	6.4250E-01
P110	4.3057E-01	P111	4.6222E-01	P112	4.6222E-01	P113	1.1019E-01	P114	4.3057E-01	P116	2.0000E-01
P117	1.0000E-01	P118	6.4250E-01	P119	1.4747E-01	P002	1.3928E-01	P003	0.0	P008	0.0
P025	2.5000E-01	P032	2.2618E-01	P034	0.0	P037	1.5000E-01	P038	1.8660E-01	P039	0.0
P044	0.0	P047	0.0	P059	0.0	P066	0.0	P067	0.0	P095	0.0
P097	0.0	P004	2.7472E-02	P005	2.2618E-01	P006	4.8431E-02	P007	1.3928E-01	P009	4.3554E-02
P010	1.0383E-01	P011	1.0383E-01	P012	4.8431E-02	P013	4.3554E-02	P015	1.1206E-01	P017	1.0000E-01
P020	7.5800E-02	P023	5.5000E-01	P026	3.4858E-02	P035	1.7930E-01	P036	4.4825E-01	P045	4.4825E-01
P046	1.7930E-01	P053	3.4858E-02	P071	0.0	P109	6.6625E-01	P115	6.6625E-01	P080	0.0
P081	0.0	P082	0.0	P051	8.8049E-02	P052	8.9459E-01	P090	0.0	P091	0.0
P102	8.8049E-02	P103	8.9459E-01	P000P	1.0000E-01	P001P	4.8431E-02	P002P	1.3928E-01	P003P	0.0
P004P	2.7472E-02	P005P	2.2618E-01	P006P	4.8431E-02	P007P	1.3928E-01	P008P	0.0	P009P	4.3554E-02
P010P	1.0383E-01	P011P	1.0383E-01	P012P	4.8431E-02	P013P	4.3554E-02	P014P	0.0	P015P	1.1206E-01
P016P	2.5000E-02	P017P	1.0000E-01	P018P	8.0000E-02	P019P	5.0000E-03	P020P	7.5800E-02	P021P	2.5000E-01
P022P	2.5000E-02	P023P	5.5000E-01	P024P	5.0000E-03	P025P	2.5000E-01	P026P	3.4858E-02	P027P	4.5000E-02
P028P	2.5000E-01	P029P	9.0000E-03	P030P	3.8300E-02	P031P	0.0	P032P	2.2618E-01	P033P	0.0
P034P	0.0	P035P	1.7930E-01	P036P	4.4825E-01	P037P	1.5000E-01	P038P	1.8660E-01	P039P	0.0
P043P	2.0000E-01	P044P	0.0	P045P	4.4825E-01	P046P	1.7930E-01	P047P	0.0	P049P	4.5000E-02
P050P	1.4747E-01	P051P	8.8049E-02	P052P	8.9459E-01	P053P	3.4858E-02	P054P	9.0000E-03	P055P	6.6667E-01
P056P	6.6667E-01	P057P	0.0	P058P	6.6667E-01	P059P	0.0	P060P	6.6667E-01	P061P	6.6667E-01
P062P	5.0000E-01	P063P	5.0000E-01	P064P	1.0000E-01	P065P	1.0000E-01	P066P	0.0	P067P	0.0
P068P	1.0000E-01	P069P	1.0000E-01	P071P	0.0	P072P	6.6667E-01	P073P	2.5000E-01	P080P	0.0
P081P	0.0	P082P	0.0	P083P	1.1019E-01	P086P	2.0000E-01	P087P	1.0000E-01	P088P	6.4250E-01
P090P	0.0	P091P	0.0	P095P	0.0	P096P	2.0000E-01	P097P	0.0	P098P	6.4250E-01
P099P	1.0000E-01	P101P	4.3060E-01	P102P	8.8049E-02	P103P	8.9459E-01	P104P	4.3060E-01	P105P	2.5000E-01
P106P	2.0000E-01	P107P	1.0000E-01	P108P	6.4250E-01	P109P	6.6625E-01	P110P	4.3057E-01	P111P	4.6222E-01
P112P	4.6222E-01	P113P	1.1019E-01	P114P	4.3057E-01	P115P	6.6625E-01	P116P	2.0000E-01	P117P	1.0000E-01
P118P	6.4250E-01	P119P	1.4747E-01	ZZ0003	0.0	ZZ0004	0.0	DUMMY	0.0		

PARAM AXLE= 2
END

DSL MESSAGE 20 NO OUTPUT REQUESTED...WARNING ONLY.

DSL/91 SIMULATION TIME= 0.0 SECONDS. 76.170 13:28:15.44

DEBUG OUTPUT, BLOCK 3 AT TIME= 0.2000E-02

TIME	2.0000E-03	DELT	1.0000E-03	DELMIN	0.0	DELMAX	7.2370E 75	TSTART	0.0	FINTIM	2.0000E-03
CLKTIM	0.0	NALARM	0.0	DELS	0.0	DELNIX	7.2370E 75	DFLADC	7.2370E 75	DELDAC	7.2370E 75
DELSTP	7.2370E 75	DELMRK	7.2370E 75	DFW2DT	3.7000E 01	DFW2	1.5000E-01	YCRDT	8.0000E 01	YCR	2.5500E 00
RPS1	4.3060E 01	RPS2	4.3060E 01	RPS3	4.3057E 01	XPS2DT	1.0000E 04	RPS4	4.3057E 01	XPS4DT	1.0000E 04
DFW1DT	3.0000E 01	DFW1	3.5000E-01	PSI1	2.1400E-01	PSI2	2.0400E-01	PSI3	1.6670E-02	PSI4	-1.5000E-02
Z0	-2.3400E 01	THE0	2.0900E-03	PHI0	3.0000E-03	RDTO	-5.0000E 02	U01	1.2000E-01	U02	1.0100E 00
U03	9.0000E-01	U04	1.2500E 00	U11	-6.1330E-01	U12	1.1100E 00	U13	1.6210E 00	U14	1.7000E 00
AM11	5.2500E 00	AM12	-7.4000E 00	AM13	-7.5000E 00	AM14	-8.3000E 00	TQFBR	8.0000E 03	TQRBR	7.1000E 03
MT1	-1.6430E 02	MT2	1.6430E 02	PDTO	-1.2000E-01	QDTO	9.0000E-02	U0	7.0400E 02	V0	1.3000E-01
W0	5.0000E-03	P0	2.0000E-02	Q0	-3.7000E-02	R0	1.1000E-02	F1	9.0000E-01	F2	8.0000E-01
F3	-3.0000E-01	F4	6.0000E-01	GB1	2.0000E-01	GB2	4.0000E-01	GB3	5.0000E-01	GB4	8.5000E-01
AMS	5.1620E 00	AMUF	3.5900E-01	AMUR	5.7400E-01	TS	3.5860E 01	AIR	8.0000E 02	RF	8.1000E 04
TF	5.4300E 01	RR	5.0000E 04	RW	1.2850E 01	AIFW	5.8150E 00	AH1	2.0000E 02	AH2	2.0000E 02
AKT1	8.1200E 02	AKT2	8.1200E 02	AKT3	1.1920E 03	AKT4	1.1920E 03	AMCR	8.0000E-02	CFCR	2.0000E 02
CCR	1.1000E 01	AP	6.0600E 00	AA1	5.5300E 00	AA2	5.5300E 00	ANG	1.7500E 01	AKSC	6.1000E 02
ESP	-6.0000E-01	AKSL1	1.1700E 05	AKSL2	1.1700E 05	EP1	-2.0000E-02	EP2	-1.0000E-02	AIWF	7.3777E 00
AID	3.0000E-01	ARBR	4.1250E 00	AIWR	7.3777E 00	CFP	2.5000E 01	CRP	4.5000E 01	TP	5.3300E 01
AKF1	1.5000E 02	AKF2	1.5000E 02	AKR3	2.0000E 02	AKR4	2.0000E 02	A	5.6300E 01	B	3.9000E 01
G	3.8640E 02	ZF	1.0800E 01	ZR	1.0600E 01	AMU1	1.7950E-01	AMU2	1.7950E-01	AMU3	2.8700E-01
HRC	4.7000E 00	CRRC	1.1000E-02	TANP	0.0	DELSWD	1.4250E 00	LB1	1.6500E 00	LB2	1.6500E 00
LB3	1.0000E 00	LB4	1.0000E 00	AICF	7.0000E-01	ARFBR	2.7000E 00	AIF	4.9800E 02	TSF	3.2250E 01
AMU4	2.8700E-01	FCTM	2.5000E 02	RCTM	4.0000E 02	HFC	7.2000E 00	SCALE	1.0000E 03	RWSF	2.0000E 01
AXLE	2.0000E 00	IDULTR	0.0	IDPSW	0.0	BETA	2.5000E-01	P014	0.0	P031	0.0
P033	0.0	P057	0.0	ZZ0001	0.0	F1F1	2.5000E 01	F1F2	2.5000E 01	F1P3	4.5000E 01
F1R4	4.5000E 01	ANTI1	4.5000E 02	ANTI2	3.0000E 02	ANTI3	3.5000E 02	ANTI4	5.0000E 02	AUXRL1	4.0740E 01
AUXRL2	-4.0740E 01	Z1P	2.1378E-01	Z2P	5.0883E-02	Z3P	2.1147E-01	Z4P	5.1577E-02	FR1	4.8459E 02
ZZ0002	0.0	FR2	1.5565E 03	FR3	5.5008E 02	FR4	2.4028E 02	FXU1	2.1540E 01	FXU2	-1.6027E 03
FXU3	-5.8931E 02	FXU4	-3.2377E 02	FYU1	1.9030E 01	FYU2	-2.4560E 02	FYU3	-3.5178E 01	FYU4	3.9317E 01
NPHIF	6.8758E 04	NPHIR	-9.6117E 03	TP	-6.0195E 04	AMSS1	-1.1831E 04	AMSS2	-3.5816E 04	DFW1DD	1.4745E 03
DFW2DD	5.4149E 03	YCRDD	-2.4537E 05	SFSF	1.0000E-01	U1	7.0330E 02	U2	7.0390E 02	U3	7.0331E 02
U4	7.0390E 02	DEL1	3.8300E-01	DEL1DT	1.0000E 01	DEL1DD	1.3036E 03	DEL2	1.8660E 00	DEL2DT	1.5000E 01
DEL2DD	-6.9607E 03	ZET1	3.8300E-01	ZET2	1.8660E 00	ZET1DT	1.0000E 01	ZET2DT	1.5000E 01	F2F1	5.7450E 01
F2F2	2.7990E 02	F3F1	1.4400E 02	F3F2	1.7230E 02	F4F1	-3.7674E 01	F4F2	3.7674E 01	S1P	2.6429E 02
S2P	-2.1794E 02	Z1	-1.2253E 01	Z2	-1.0933E 01	V1	2.8824E-01	V2	3.1464E-01	W1	-7.3689E 00
W2	1.6545E 01	A005A	-1.5000E-01	A007A	1.8660E-01	A014A	1.5000E-01	D005D	-1.7402E 00	D007D	-3.7500E-02
DEL3	2.5000E-01	DEL3DT	6.9000E 01	DEL3DD	-9.2161E 02	DEL4	1.5000E-01	DEL4DT	7.0000E 01	DEL4DD	7.5058E 02
ZET3	2.5000E-01	ZET4	1.5000E-01	ZET3DT	6.9000E 01	ZET4DT	7.0000E 01	F2R3	5.0000E 01	F2R4	3.0000E 01
F3R4	6.4500E 02	F3R3	6.4270E 02	S3P	-3.8946E 02	S4P	-2.1824E 02	Z3	-1.2389E 01	Z4	-1.2648E 01
V3	-7.5877E-01	V4	-7.6397E-01	W3	7.0981E 01	W4	6.8029E 01	A015A	-7.0000E-01	A017A	1.5000E-02
D017D	-1.7500E-01	D015D	1.8765E-01	SMP	-5.6135E 02	S1	6.7242E 02	S2	1.9019E 02	S3	1.9971E 02
S4	3.7093E 02	UG1	7.0329E 02	UG2	7.0393E 02	UG3	7.0346E 02	UG4	7.0404E 02	VG1	3.1034E-01
VG2	2.6500E-01	VG3	-9.7171E-01	VG4	-9.6805E-01	UG1P	6.8731E 02	UG2P	6.8939E 02	UG3P	7.0345E 02
UG4P	7.0406E 02	XI1	2.3233E-01	XI2	3.1711E-01	XI3	2.4172E-01	XI4	2.2648E-01	SLIP1	2.3233E-01
SLIP2	3.1711E-01	SLIP3	2.4172E-01	SLIP4	2.2648E-01	AM21	-7.3330E-01	AM22	1.0000E-01	AM23	7.2100E-01
AM24	4.5000E-01	SI1	2.0056E-02	SI2	-1.3467E-01	SI3	-1.0948E-01	SI4	-1.4286E-01	U1P	-5.0371E-02
U2P	1.0417E 00	U3P	1.0743E 00	U4P	1.3519E 00	FC1	2.4409E 01	FC2	-1.6214E 03	FC3	-5.9093E 02
FC4	-3.2484E 02	AIFBR	8.3227E 00	AIFBRP	9.4500E-01	AIBR	8.6539E 00	AIBRP	1.2762E 00	RPS1DT	1.7486E 03
RPS2DT	4.1920E 03	RPS3DT	1.9172E 02	RPS4DT	1.2669E 03	TIN	1.0000E-04	P000	1.0000E-01	P001	4.8431E-02
P016	2.5000E-02	P018	2.5000E-02	P019	5.0000E-03	P021	2.5000E-01	P022	2.5000E-02	P024	5.0000E-03
P027	4.5000E-02	P028	2.5000E-01	P029	9.0000E-03	P030	3.8200E-02	P043	6.9000E-01	P049	4.5000E-02
P050	1.4747E-01	P054	9.0000E-03	P055	6.6667E-01	P056	6.6667E-01	P058	6.6667E-01	P060	6.6667E-01

P061	6.6667E-01	P062	5.0000E-01	P063	5.0000E-01	P064	1.0000E-01	P065	1.0000E-01	P068	1.0000E-01
P069	1.0000E-01	P072	6.6667E-01	P073	2.5000E-01	P083	1.1019E-01	P085	2.5000E-01	P086	2.0000E-01
P087	1.0000E-01	P088	6.4250E-01	P096	2.0000E-01	P098	6.4250E-01	P099	1.0000E-01	P100	2.5000E-01
P101	4.3060E-01	P104	4.3060E-01	P105	2.5000E-01	P106	2.0000E-01	P107	1.0000E-01	P108	6.4250E-01
P110	4.3057E-01	P111	4.6222E-01	P112	4.6222E-01	P113	1.1019E-01	P114	4.3057E-01	P116	2.0000E-01
P117	1.0000E-01	P118	6.4250E-01	P119	1.4747E-01	P002	1.3928E-01	P003	0.0	P008	0.0
P025	2.5000E-01	P032	2.2618E-01	P034	0.0	P037	1.5000E-01	P038	1.8660E-01	P039	0.0
P044	0.0	P047	0.0	P059	0.0	P066	0.0	P067	0.0	P095	0.0
P097	0.0	P004	2.7472E-02	P005	2.2618E-01	P006	4.8431E-02	P007	1.3923E-01	P009	0.0
P010	2.0767E-01	P011	0.0	P012	4.8431E-02	P013	8.7108E-02	P015	0.0	P017	2.5000E-01
P020	1.5000E-02	P023	7.0000E-01	P026	0.0	P035	0.0	P036	0.0	P045	0.0
P046	0.0	P053	0.0	P071	1.7600E-01	P109	0.0	P115	0.0	P080	2.0767E-01
P081	8.7108E-02	P082	4.8431E-02	P051	8.8049E-02	P052	8.9459E-01	P090	0.0	P091	0.0
P102	8.8049E-02	P103	8.9459E-01	P000P	1.0000E-01	P001P	4.8431E-02	P002P	1.3928E-01	P003P	0.0
P004P	2.7472E-02	P005P	2.2618E-01	P006P	4.8431E-02	P007P	1.3928E-01	P008P	0.0	P009P	0.0
P010P	2.0767E-01	P011P	0.0	P012P	4.8431E-02	P013P	8.7108E-02	P014P	0.0	P015P	0.0
P016P	2.5000E-02	P017P	2.5000E-01	P018P	2.5000E-02	P019P	5.0000E-03	P020P	1.5000E-02	P021P	2.5000E-01
P022P	2.5000E-02	P023P	7.0000E-01	P024P	5.0000E-03	P025P	2.5000E-01	P026P	0.0	P027P	4.5000E-02
P028P	2.5000E-01	P029P	9.0000E-03	P030P	3.8300E-02	P031P	0.0	P032P	2.2618E-01	P033P	0.0
P034P	0.0	P035P	0.0	P036P	0.0	P037P	1.5000E-01	P038P	1.8660E-01	P039P	0.0
P043P	6.9000E-01	P044P	0.0	P045P	0.0	P046P	0.0	P047P	0.0	P049P	4.5000E-02
P050P	1.4747E-01	P051P	8.8049E-02	P052P	8.9459E-01	P053P	0.0	P054P	9.0000E-03	P055P	6.6667E-01
P056P	6.6667E-01	P057P	0.0	P058P	6.6667E-01	P059P	0.0	P060P	6.6667E-01	P061P	6.6667E-01
P062P	5.0000E-01	P063P	5.0000E-01	P064P	1.0000E-01	P065P	1.0000E-01	P066P	0.0	P067P	0.0
P068P	1.0000E-01	P069P	1.0000E-01	P071P	1.7600E-01	P072P	6.6667E-01	P073P	2.5000E-01	P080P	2.0767E-01
P081P	8.7108E-02	P082P	4.8431E-02	P083P	1.1019E-01	P086P	2.0000E-01	P087P	1.0000E-01	P088P	6.4250E-01
P090P	0.0	P091P	0.0	P095P	0.0	P096P	2.0000E-01	P097P	0.0	P098P	6.4250E-01
P099P	1.0000E-01	P101P	4.3060E-01	P102P	8.8049E-02	P103P	8.9459E-01	P104P	4.3060E-01	P105P	2.5000E-01
P106P	2.0000E-01	P107P	1.0000E-01	P108P	6.4250E-01	P109P	0.0	P110P	4.3057E-01	P111P	4.6222E-01
P112P	4.6222E-01	P113P	1.1019E-01	P114P	4.3057E-01	P115P	0.0	P116P	2.0000E-01	P117P	1.0000E-01
P118P	6.4250E-01	P119P	1.4747E-01	ZZ0003	0.0	ZZ0004	0.0	DUMMY	0.0		

```
            *** DSL/91  SIMULATION DATA ***                                         76.173        14:23:53.81
       TITLE === PROB052 VEHICLE SIMULATION ===
       INCON  DFW2DT=37.    ,DFW2   =0.15   ,YCRDT =80.     ,YCR    =2.55
       INCON  RPS1   =43.06 ,RPS2   =43.06  ,RPS3   =43.057,XPS2DT=10000.
       INCON  RPS4   =43.057,XPS4DT=10000.,DFW1DT=30.     ,DFW1   =0.35
       INCON  PSI1   =.2140 ,PSI2   =.2040  ,PSI3   =.01667,PSI4   =-.0150
       INCON  ZO     =-23.4 ,THEO   =.00209,PHIO   =.00300,RDTO   =-500.0
       INCON  U01    =.120  ,U02    =1.01   ,U03    =.900   ,U04    =1.250
       INCON  U11    =-.6133,U12    =1.11   ,U13    =1.621  ,U14    =1.700
       INCON  AM11   =5.25  ,AM12   =-7.40  ,AM13   =-7.50  ,AM14   =-8.30
       INCON  TQFBR =8000.  ,TQRBR =7100.   ,MT1    =-164.3,MT2    =164.3
       INCON  PDTO   =-.12  ,QDTO   =.0900  ,UO     =704.   ,VO     =.1300
       INCON  WO     =.0050 ,PO     =.0200  ,QO     =-.0370,RO     =.0110
       INCON  F1     =.9    ,F2     =.8     ,F3     =-.3    ,F4     =.6
       INCON  GB1    =.2    ,GB2    =.4     ,GB3    =.5     ,GB4    =.85
       PARAM  AMS    =5.162 ,AMUF   =0.359  ,AMUR   =0.574  ,TS     = 35.86
       PARAM  AIR    =800.  ,RF     =81E03  ,TF     =54.3   ,RR     =50E03
       PARAM  RW     =12.85 ,AIFW   =5.815  ,AH1     =200.  ,AH2    =200.
       PARAM  AKT1   =812.  ,AKT2   =812.   ,AKT3   =1192.  ,AKT4   =1192.
       PARAM  AMCR   =0.08  ,CFCR   =200.   ,CCR    =11.    ,AP     =6.06
       PARAM  AA1    =5.53  ,AA2    =5.53   ,ANG    =17.5   ,AKSC   =610.
       PARAM  ESP    =-.6   ,AKSL1 =1.17E5,AKSL2 =1.17E5,EP1    =-.0200
       PARAM  EP2    =-.01  ,AIWF   =7.3777,AID    =0.3    ,ARBR   =4.125
       PARAM  AIWR   =7.3777,CFP    =25.    ,CRP    =45.    ,TR     =53.3
       PARAM  AKF1   =150.  ,AKF2   =150.   ,AKR3   =200.   ,AKR4   =200.
       PARAM  A      =56.3  ,B      =39.0   ,G      =386.4  ,ZF     =10.8
       PARAM  ZR     =10.6  ,AMU1   =.1795  ,AMU2   =.1795  ,AMU3   =.2870
       PARAM  HRC    =4.70  ,CRRC   =0.0110,TANP   =0.0    ,DELSWO=1.425
       PARAM  LB1    =1.65  ,LB2    =1.65   ,LB3    =1.0    ,LB4    =1.0
       PARAM  AIDF   = .7   ,ARFBR = 2.7    ,AIF    = 498.  ,TSF    = 32.25
       PARAM  AMU4   =.2870 ,FOTM   = 250.  ,ROTM   = 400.  ,HFC    =7.20
       PARAM SCALE = 1000. ,RWSF   =20.
       PARAM  AXLE   =1
       PARAM   IDULTR= 0
       PARAM   IDRSW= 0
       PARAM  BETA   =0.25
       CONTRL TSTART=0.0,FINTIM=.002,DELT=.001
       END

***DSL MESSAGE 20***    NO OUTPUT REQUESTED...WARNING ONLY.

DSL/91  SIMULATION TIME=   0.0  SECONDS.                                        76.173        14:23:54.90

 DEBUG OUTPUT, BLOCK   3 AT TIME=  0.2000E-02
```

TIME	2.0000E-03	DELT	1.0000E-03	DELMIN	0.0	DELMAX	7.2370E 75	TSTART	0.0	FINTIM	2.0000E-03
CLKTIM	0.0	NALARM	0.0	DELS	0.0	DELNIX	7.2370E 75	DELADC	7.2370E 75	DELDAC	7.2370E 75
DELSTP	7.2370E 75	DELMRK	7.2370E 75	DFW2DT	3.7000E 01	DFW2	1.5000E-01	YCRDT	8.0000E 01	YCR	2.5500E 00
RPS1	4.3060E 01	RPS2	4.3060E 01	RPS3	4.3057E 01	XPS2DT	1.0000E 04	RPS4	4.3057E 01	XPS4DT	1.0000E 04
DFW1DT	3.0000E 01	DFW1	3.5000E-01	PSI1	2.1400E-01	PSI2	2.0400E-01	PSI3	1.6670E-02	PSI4	-1.5000E-02
ZO	-2.3400E 01	THEO	2.0900E-03	PHIO	3.0000E-03	RDTO	-5.0000E 02	U01	1.2000E-01	U02	1.0100E 00
U03	9.0000E-01	U04	1.2500E 00	U11	-6.1330E-01	U12	1.1100E 00	U13	1.6210E 00	U14	1.7000E 00
AM11	5.2500E 00	AM12	-7.4000E 00	AM13	-7.5000E 00	AM14	-8.3000E 00	TQFBR	8.0000E 03	TQRBR	7.1000E 03
MT1	-1.6430E 02	MT2	1.6430E 02	PDTO	-1.2000E-01	QDTO	9.0000E-02	UO	7.0400E 02	VO	1.3000E-01
WO	5.0000E-03	PO	2.0000E-02	QO	-3.7000E-02	RO	1.1000E-02	F1	9.0000E-01	F2	8.0000E-01
F3	-3.0000E-01	F4	6.0000E-01	GB1	2.0000E-01	GB2	4.0000E-01	GB3	5.0000E-01	GB4	8.5000E-01
AMS	5.1620E 00	AMUF	3.5900E-01	AMUR	5.7400E-01	TS	3.5860E 01	AIR	8.0000E 02	RF	8.1000E 04
TF	5.4300E 01	RR	5.0000E 04	RW	1.2850E 01	AIFW	5.8150E 00	AH1	2.0000E 02	AH2	2.0000E 02
AKT1	8.1200E 02	AKT2	8.1200E 02	AKT3	1.1920E 03	AKT4	1.1920E 03	AMCR	8.0000E-02	CFCR	2.0000E 02
CCR	1.1000E 01	AP	6.0600E 00	AA1	5.5300E 00	AA2	5.5300E 00	ANG	1.7500E 01	AKSC	6.1000E 02
ESP	-6.0000E-01	AKSL1	1.1700E 05	AKSL2	1.1700E 05	EP1	-2.0000E-02	EP2	-1.0000E-02	AIWF	7.3777E 00
AID	3.0000E-01	ARBR	4.1250E 00	AIWR	7.3777E 00	CFP	2.5000E 01	CRP	4.5000E 01	TR	5.3300E 01
AKF1	1.5000E 02	AKF2	1.5000E 02	AKR3	2.0000E 02	AKR4	2.0000E 02	A	5.6300E 01	B	3.9000E 01

G	3.8640E 02	ZF	1.0800E 01	ZR	1.0600E 01	AMU1	1.7950E-01	AMU2	1.7950E-01	AMU3	2.8700E-01
HRC	4.7000E 00	CRRC	1.1000E-02	TANP	0.0	DELSWO	1.4250E 00	LB1	1.6500E 00	LB2	1.6500E 00
LB3	1.0000E 00	LB4	1.0000E 00	AIDF	7.0000E-01	ARFBR	2.7000E 00	AIF	4.9800E 02	TSF	3.2250E 01
AMU4	2.8700E-01	FOTM	2.5000E 02	ROTM	4.0000E 02	HFC	7.2000E 00	SCALE	1.0000E 03	RWSF	2.0000E 01
AXLE	1.0000E 00	IDULTR	0.0	IDRSW	0.0	BETA	2.5000E-01	ZZ0001	0.0	F1F1	2.5000E 01
F1F2	2.5000E 01	F1R3	4.5000E 01	F1R4	4.5000E 01	ANTI1	4.5000E 02	ANTI2	3.0000E 02	ANTI3	3.5000E 02
ANTI4	5.0000E 02	AUXRL1	4.0740E 01	AUXRL2	-4.0740E 01	Z1P	2.1378E-01	Z2P	5.0883E-02	Z3P	2.1147E-01
Z4P	5.1577E-02	FR1	4.8459E 02	ZZ0002	0.0	FR2	1.5565E 03	FR3	1.8077E 03	FR4	4.1310E 02
FXU1	2.1540E 01	FXU2	-1.6027E 03	FXU3	-2.0205E 03	FXU4	-5.5828E 02	FYU1	1.9030E 01	FYU2	-2.4560E 02
FYU3	-1.1700E 02	FYU4	6.7620E 01	NPHIF	6.8758E 04	NPHIR	-4.4863E 04	TP	-6.0195E 04	AMSS1	-1.1831E 04
AMSS2	-3.5816E 04	DFW1DD	1.4745E 03	DFW2DD	5.4149E 03	YCRDD	-2.4537E 05	SFSF	1.0000E-01	U1	7.0330E 02
U2	7.0390E 02	U3	7.0331E 02	U4	7.0390E 02	DEL1	3.8300E-01	DEL1DT	1.0000E 01	DEL1DD	1.4017E 03
DEL2	1.8660E 00	DEL2DT	1.5000E 01	DEL2DD	-6.8627E 03	ZET1	3.8300E-01	ZET2	1.8660E 00	ZET1DT	1.0000E 01
ZET2DT	1.5000E 01	F2F1	5.7450E 01	F2F2	2.7990E 02	F3F1	1.4400E 02	F3F2	1.7230E 02	F4F1	0.0
F4F2	0.0	S1P	2.6429E 02	S2P	-2.1794E 02	Z1	-1.2253E 01	Z2	-1.0933E 01	V1	2.8824E-01
V2	3.1464E-01	W1	-7.3689E 00	W2	1.6545E 01	A005A	-1.5000E-01	A007A	1.8660E-01	A014A	1.5000E-01
D005D	-1.7157E 00	D007D	-3.7500E-02	DEL3	8.0000E-01	DEL3DT	2.0000E 01	DEL3DD	-1.6207E 03	DEL4	1.8950E-02
DEL4DT	5.5000E-01	DEL4DD	-5.6191E 01	ZET3	1.1398E 00	ZET4	4.6023E-01	ZET3DT	2.9861E 01	ZET4DT	1.0139E 01
F2R3	2.2795E 02	F2R4	9.2045E 01	F3R4	1.9590E 02	F3R3	3.4560E 02	S3P	-2.9498E 02	S4P	1.9348E 02
Z3	-1.1334E 01	Z4	-1.2503E 01	V3	-6.9711E 00	V4	-7.1378E 00	W3	3.6638E 01	W4	3.3715E 00
A015A	-5.5000E-01	A017A	7.5800E-02	D017D	-5.5000E-02	D015D	-1.4048E 00	SMP	-5.5149E 01	S1	6.7242E 02
S2	1.9019E 02	S3	2.9419E 02	S4	7.8265E 02	UG1	7.0329E 02	UG2	7.0393E 02	UG3	7.0339E 02
UG4	7.0391E 02	VG1	3.1034E-01	VG2	2.6500E-01	VG3	-7.0810E 00	VG4	-7.1479E 00	UG1P	6.8731E 02
UG2P	6.8939E 02	UG3P	7.0327E 02	UG4P	7.0401E 02	XI1	2.3233E-01	XI2	3.1711E-01	XI3	3.0612E-01
XI4	2.3530E-01	SLIP1	2.3233E-01	SLIP2	3.1711E-01	SLIP3	3.0612E-01	SLIP4	2.3530E-01	AM21	-7.3330E-01
AM22	1.0000E-01	AM23	7.2100E-01	AM24	4.5000E-01	SI1	2.0056E-02	SI2	-1.3467E-01	SI3	-1.0948E-01
SI4	-1.4286E-01	U1P	-5.0371E-02	U2P	1.0417E 00	U3P	1.1207E 00	U4P	1.3559E 00	FC1	2.4409E 01
FC2	-1.6214E 03	FC3	-2.0259E 03	FC4	-5.6011E 02	AIFBR	8.3227E 00	AIFBRP	9.4500E-01	AIBR	8.6539E 00
AIBRP	1.2762E 00	RPS1DT	1.7486E 03	RPS2DT	4.1920E 03	RPS3DT	1.9989E 03	RPS4DT	1.3349E 03	TIN	1.0000E-04
A250	4.0000E-01	A251	-8.5000E-01	A260	-3.7000E-01	A261	3.0000E-01	A280	-3.0000E-01	A281	7.0000E-01
A227	-3.0000E-02	A228	3.5000E-01	A229	1.5000E-01	A230	-1.4400E-01	A231	-1.7230E-01	A232	-3.4560E-01
A233	-1.9590E-01	A237	-7.0000E-02	A238	1.1794E-02	A239	1.3206E-02	A240	-1.0000E-01	A241	-1.5000E-01
A242	-2.9861E-01	A243	2.9861E-01	A244	-1.0138E-01	A245	1.0138E-01	A247	1.0000E-01	A248	1.5000E-01
A252	4.9073E-01	A254	-1.0000E 00	A262	6.2224E-01	A263	-6.1224E-01	A264	6.1224E-01	A270	5.9389E-01
A271	-3.0000E-01	A272	-5.6389E-01	A273	-4.0000E-01	A274	-1.4250E-01	A282	2.2224E-01	A283	-2.0224E-01
A284	2.0224E-01	A292	-2.0000E-01	A293	-1.0000E-01	A210	-1.4400E-01	A211	-1.7230E-01	A212	-3.4560E-01
A213	-1.9590E-01	A215	-1.3206E-03	A216	1.4250E-02	A217	-1.1794E-03	A218	-7.0000E-01	A219	-3.0000E-01
D250	-3.0671E 00	D251	-6.6667E-01	D260	-1.3537E 00	D261	1.8500E 00	D280	-3.6863E-01	D281	1.5000E 00
DAC00	-4.7175E 02	DAC16	1.4250E-01	DAC02	-5.2825E 02	Q202	3.1250E-01	Q204	1.6667E-01	Q205	4.0000E-01
Q206	8.5000E-01	Q208	3.7000E-01	Q209	3.0000E-01	Q212	1.1573E 00	Q214	1.2575E-01	Q219	4.4039E-02
Q222	8.5984E-02	Q224	1.2575E-01	Q235	3.0000E-01	Q236	7.0000E-01	Q257	1.0000E-02	Q258	1.1000E-01
Q267	5.2893E-02	Q268	5.4250E-01	Q277	1.0000E-01	Q287	5.4250E-01	Q288	5.2893E-02	P215	2.4997E-01
P217	8.6634E-02	P230	2.4997E-01	P235	1.0000E-01	P236	1.0000E-01	P237	1.0000E-01	P210	1.4400E 00
P211	1.1487E 00	P213	1.9322E 00	Q215	1.1794E-03	Q216	1.4250E-02	Q217	1.3206E-03	Q218	7.0000E-01
P219	3.0000E-01	ZZ0003	0.0	ZZ0004	0.0	DUMMY	0.0				

2. PRESENTED HERE IS THE COMPUTER LISTING OF THE IBM 360/91 FORTRAN DIGITAL PROGRAM

2.1 SUBROUTINES

2.1.1 MAIN

PRESENTED HERE IS THE FORTRAN LISTING FOR THE MAIN PROGRAM. CONTROL OF THE PROGRAM FLOW IS PERFORMED IN THIS PROGRAM.

```
C     VEHICLE HANDLING  MODEL C
C     MAIN PROGRAM
C*****************************************************************************
C     THIS PROGRAM CONTROLS THE PROGRAM FLOW
C*****************************************************************************
 8888 CONTINUE
      CALL OSXNTL
      CALL USERIN
      CALL VHTPIC
      CALL NITIAL
      CALL SBPG22
      CALL NTIAL1
      CALL POTSET
      CALL NTRACT(&8888,&1000,&2000,&3000)
 1000 CONTINUE
      CALL VHTPIC
      CALL NITIAL
      CALL SBPG22
      CALL NTIAL1
      CALL POTSET
      CALL NTRAT1(&8888,&1000,&2000,&3000)
 2000 CONTINUE
      CALL RTMON
      CALL CMPVAR
      CALL NTRAT2(&8888,&1000,&2000,&3000)
 3000 CONTINUE
      STOP
      END
```

2.1.2 OSXNTL

PRESENTED HERE IS THE FORTRAN LISTING FOR THE OSXNTL SUBPROGRAM. THE FOLLOWING IS PERFORMED IN OSXNTL:

1) Initialization of the OS options executive which includes the reading of data cards for table and track variables, ADC and DAC assignments and all initial values for interactive variables.

2) Communication initialization with the hybrid operator's station.

```
C     SUBROUTINE OSXNTL
      SUBROUTINE OSXNTL
C ***********************************************************************
C
C     THIS SUBROUTINE INITIALIZES THE OS OPTIONS EXECUTIVE
C     INCLUDING THE READING OF DATA CARDS FOR TABLE AND TRACK VARIABLES
C     ,ADC AND DAC ASSIGNMENTS, AND ALL INITIAL
C     VALUES FOR INTERACTIVE VARIABLES. IT ALSO ESTABLISHES
C     COMMUNICATION INITIALIZATION WITH THE HYBRID OPERATOR'S STATION
C
C ***********************************************************************
C
C**************************** COMMON AREAS *******************************
C
      COMMON/START/ ZDUMMY(4)
      COMMON/VHTPNM/ TABVAR,INDVAR,WRDVNT
      COMMON/OSTRAN/ ICT,IRT,MOPU,IRUNS,LRUNS,REALT,ITRUNS
      COMMON/DACADC/ NAMDAC,NAMADC,IDAC,IADC,ADCNUM,DACNUM
      COMMON/TABBS/ ITABP,ITABI,ITNAM,TABNUM
      COMMON/DEVICE/KEYBD,ITTY,ICDRD,LPTR,LPNT
      COMMON/OSMON/ IREALT,NNNN
      COMMON/IO/ DACPLA,ADCPLA,SCALDC,SCALAC
      COMMON/TRACK/JIN,IKEEP,ATRACK,ISAMP,ONTIM,OFFTIM,ITRA,
     1 ITRAA,ITRNA,ITRIA
      COMMON/UNREAD/NAMEA,IWRDCT,INUMCT,LSTART,INDEXA,
     1 FNUMA,LAST,ILOP
      COMMON/FIND/ORNAME(400),NCOM,RSVAL(002),IORDER(400)
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      COMMON/TIMBLK/JJTIME,TIME,DT
C
C************************************************************************
C
      REAL*8 LMNAME
      REAL*8 VEHICL
      REAL*8 TABVAR(9,7)
      REAL*8 NAMEA(10)
      REAL*8 ORNAME
      REAL*8 ENDDAC,ENDADC
      REAL*4 ZDUMMY
      REAL*4 FNUMA(10)
      REAL*4                  SCALAC(48),SCALDC(48)
      REAL*4 IPOT,IPOTAD
      INTEGER*4 INDEXA(10)
      INTEGER*4 ITABP(9),TABNUM,ITNAM(9)
      INTEGER*4 ITABI(9)
      INTEGER*2 WRDVNT(9)
      INTEGER*2 INDVAR(9,7)
      INTEGER*2 ITRAA(50),ITRNA(50),ITRIA(50)
      INTEGER*2 DACNUM,ADCNUM,DACPLA(48),ADCPLA(48)
      INTEGER*2 NAMDAC(48),NAMADC(48),IDAC(48),IADC(48)
      EQUIVALENCE (BVALUE(1),ZDUMMY(1))
      EQUIVALENCE (BVALUE(1),IVALUE(1))
      DATA ENDDAC/'ENDNODAC'/,ENDADC/'ENDNOADC'/
      DIMENSION ATRACK(2000)
      DIMENSION BVALUE(2)
      DIMENSION IVALUE(2)
C
C ***********************************************************************
C
```

```
      KEYBD=5
      ITTY=6
      ICDRD  = 1
      LAST=72
      LPTR   =2
      LPNT = 0
      CALL TYPER2(KEYBD,ITTY,LPNT)
      CALL SETUP(ITTY,ICDRD)
      IRT=0
      IKEEP=0
      JIN=0
      TABNUM=9
      MOPU=6
      LRUNS=0
      IRUNS=1
      ICT=0
      LSTART=1
      ADCNUM=48
      DACNUM=48
      ITRUNS=0
      REALT=1.
      ONTIM=1000.
      NNNN=0
C
C     THIS SECTION WRITES THE PROBLEM TITLE AND LOAD MODULE NAME
C
      WRITE(ITTY,11)
   11 FORMAT(T10,'HYBRID VEHICLE HANDLING PROGRAM')
      READ(ICDRD ,101) NUM,LMNAME,VEHICL
101   FORMAT(I3,A8,A8)
      WRITE(ITTY,201) NUM,LMNAME,VEHICL
      WRITE(LPTR,201) NUM,LMNAME,VEHICL
201   FORMAT(1H0,' HYBRID COMPUTER PROB# ',I3/A8,'  LOAD MODULE'/
     1 A8,' VEHICLE'//)
      WRITE(ITTY,301)
301   FORMAT(1H0,' ENGAGE PATCH PANEL FOR TEST')
      WRITE(ITTY,401)
401   FORMAT(1H ,' TYPE CR WHEN READY')
      READ(KEYBD,151) LL
151   FORMAT(I1)
C
C ***********************************************************************
C
C#####--- THIS ROUTINE SETS UP TRACK NAME ARRAY
      ITRA=0
  130 CALL UNFORM(ICDRD,1)
      IF(IWRDCT.EQ.0) GO TO 120
      DO 110 I=1,IWRDCT
      CALL FINDNM(K,J,I,&110)
      IF(ITRA.GE.50) WRITE(ITTY,4010) ORNAME(J)
      IF(ITRA.GE.50) GO TO 110
 4010 FORMAT(1H ,'ERROR TRACK TABLE EXCEEDED,LAST NAME WAS',A6)
      ITRA=ITRA+1
      ITRAA(ITRA)=K
      ITRNA(ITRA)=J
      ITRIA(ITRA)=INDEXA(I)
  110 CONTINUE
      GO TO 130
  120 CONTINUE
C#####--- THIS ROUTINE SETS UP TABLE NAME ARRAY
```

```
      DO 10101 JJ=1,7                                                   OSXN1190
      CALL UNFORM(ICDRD,1)                                              OSXN1200
      TABNUM=IWRDCT                                                     OSXN1210
      DO 102 LL=1,TABNUM                                                OSXN1220
      TABVAR(LL,JJ) = NAMEA(LL)                                         OSXN1230
      INDVAR(LL,JJ) = INDEXA(LL)                                        OSXN1240
  102 CONTINUE                                                          OSXN1250
      WRDVNT(JJ) = TABNUM                                               OSXN1260
10101 CONTINUE                                                          OSXN1270
C#####--- THIS ROUTINE SETS UP DAC NAMES & SCALING                      OSXN1280
      N = 0                                                             OSXN1290
  105 CALL UNFORM(ICDRD,1)                                              OSXN1300
      IF(NAMEA(1).EQ.ENDDAC) GO TO 106                                  OSXN1310
      IF(ILOP.NE.LAST) WRITE(ITTY,4000)                                 OSXN1320
      IF(IWRDCT.NE.INUMCT) WRITE(ITTY,4002)                             OSXN1330
      DO 9007 I=1,IWRDCT                                                OSXN1340
      CALL FINDNM(K,J,I,&105)                                           OSXN1350
      N = N+1                                                           OSXN1360
      IF(N.GT.DACNUM) WRITE(ITTY,4005) NAMEA(I)                         OSXN1370
 4005 FORMAT(1H0,' ERROR *-DAC ARRAY > 48-* LAST VARIABLE WAS ',A8)     OSXN1380
      IF(N.GT.DACNUM) GO TO 105                                         OSXN1390
      NAMDAC(N) = J                                                     OSXN1400
      DACPLA(N) = K                                                     OSXN1410
      SCALDC(N) = FNUMA(I)                                              OSXN1420
      IDAC(N) = INDEXA(I)                                               OSXN1430
 9007 CONTINUE                                                          OSXN1440
      GO TO 105                                                         OSXN1450
  106 CONTINUE                                                          OSXN1460
      DACNUM = N                                                        OSXN1470
      IF(DACNUM.GE.48) DACNUM=48                                        OSXN1480
C#####--- THIS ROUTINE SETS UP ADC NAMES & SCALING                      OSXN1490
      N = 0                                                             OSXN1500
  108 CALL UNFORM(ICDRD,1)                                              OSXN1510
      IF(NAMEA(1).EQ.ENDADC) GO TO 109                                  OSXN1520
      IF(ILOP.NE.LAST) WRITE(ITTY,4000)                                 OSXN1530
      IF(IWRDCT.NE.INUMCT) WRITE(ITTY,4002)                             OSXN1540
      DO 1269 I=1,IWRDCT                                                OSXN1550
      CALL FINDNM(K,J,I,&108)                                           OSXN1560
      N = N+1                                                           OSXN1570
      IF(N.GT.ADCNUM) WRITE(ITTY,4008) NAMEA(I)                         OSXN1580
 4008 FORMAT(1H0,' ERROR *-ADC ARRAY > 48-* LAST VARIABLE WAS ',A8)     OSXN1590
      IF(N.GT.ADCNUM) GO TO 108                                         OSXN1600
      NAMADC(N) = J                                                     OSXN1610
      ADCPLA(N) = K                                                     OSXN1620
      IADC(N) = INDEXA(I)                                               OSXN1630
      SCALAC(N) = FNUMA(I)                                              OSXN1640
 1269 CONTINUE                                                          OSXN1650
      GO TO 108                                                         OSXN1660
  109 CONTINUE                                                          OSXN1670
      ADCNUM = N                                                        OSXN1680
      IF(ADCNUM.GE.48) ADCNUM=48                                        OSXN1690
C#####--- THIS ROUTINE READS IN FLOATING POINT NAMES AND VALUES ---#####OSXN1700
   90 CALL UNFORM(ICDRD,1)                                              OSXN1710
      IF(IWRDCT.EQ.0) GO TO 70                                          OSXN1720
      IF(ILOP.NE.LAST) WRITE(ITTY,4000)                                 OSXN1730
      IF(IWRDCT.NE.INUMCT) WRITE(ITTY,4002)                             OSXN1740
      DO 80 I=1,IWRDCT                                                  OSXN1750
      CALL FINDNM(K,J,I,&90)                                            OSXN1760
      BVALUE(K) = FNUMA(I)                                              OSXN1770
   80 CONTINUE                                                          OSXN1780
```

```
      GO TO 90                                                          OSXN1790
   70 CONTINUE                                                          OSXN1800
C#####--- THIS ROUTINE READS IN FIX POINT NAMES AND VALUES ---#####     OSXN1810
   91 CALL UNFORM(ICDRD,1)                                              OSXN1820
      IF(IWRDCT.EQ.0) GO TO 71                                          OSXN1830
      IF(ILOP.NE.LAST) WRITE(ITTY,4000)                                 OSXN1840
      IF(IWRDCT.NE.INUMCT) WRITE(ITTY,4002)                             OSXN1850
      DO 81 I=1,IWRDCT                                                  OSXN1860
      CALL FINDNM(K,J,I,&91)                                            OSXN1870
      IVALUE(K) = IFIX(FNUMA(I))                                        OSXN1880
   81 CONTINUE                                                          OSXN1890
      GO TO 91                                                          OSXN1900
   71 CONTINUE                                                          OSXN1910
 4000 FORMAT(1H0,' MAXIMUM 10 PAIRS PER DATA CARD - COLUMNS 1 THRU 72') OSXN1920
 4002 FORMAT(1H0,' DATA MUST BE ENTERED IN PAIRS - NAME AND VALUE')     OSXN1930
  810 CONTINUE                                                          OSXN1940
C                                                                       OSXN1950
C ***********************                                               OSXN1960
C *                     *                                               OSXN1970
C * INITIALIZATION PASS *                                               OSXN1980
C *                     *                                               OSXN1990
C ***********************                                               OSXN2000
C                                                                       OSXN2010
      DO 1701 I=1,120                                                   OSXN2020
      IPOT(I)=100000.                                                   OSXN2030
      IPOTAD(I)=100000.                                                 OSXN2040
 1701 CONTINUE                                                          OSXN2050
C                                                                       OSXN2060
      CALL SACN(1,ISACNE)                                               OSXN2070
      CALL SAMO(1,ISAMOE)                                               OSXN2080
      CALL SLMO(3,ISLMOE)                                               OSXN2090
      CALL SLMO(1,ISLMOE)                                               OSXN2100
C                                                                       OSXN2110
      RETURN                                                            OSXN2120
      END                                                               OSXN2130
```

2.1.3 USERIN

PRESENTED HERE IS THE FORTRAN LISTING FOR THE USERIN SUBPROGRAM. THE FOLLOWING IS PERFORMED:

Reading of data cards for vehicle functions and parameters.

```
C     SUBROUTINE USERIN
      SUBROUTINE USERIN
C*************************************************************************************
C     THIS SUBPROGRAM READS DATA CARDS FOR VEHICLE FUNCTIONS
C     AND PARAMETERS
C*************************************************************************************
      COMMON/VHTPDT/ PARMNO,VHTPAR
      COMMON/DEVICE/KEYBD,ITTY,ICDRD,LPTR,LPNT
      COMMON/APL/ OPEN  ,RTSW  ,LDTSW ,RBSW
      COMMON/SPRING/  DLSUS1,DLSUS2,DLSUS3,DLSUS4,DELSF1(10),DELSF2(10),
     1DELSR3(10),DELSR4(10),FDLSF1(10),FDLSF2(10),FDLSR3(10),FDLSR4(10),
     1NDELF1,NDELF2,NDELR3,NDELR4
      COMMON/AROTBS/ TAU(20),CX(20),CY(20),CZ(20),CL(20),
     1CM(20),CN(20), ALPHA(20),DELCX(20),NCX,NCY,NCZ,
     1NCL,NCM,NCN,NDCX,XWP(20),VYWTB(20),NWP
      COMMON/NEWTBS/TQBF(20),PBF(20),TQBR(20),PBR(20),
     1AFA(20),GAMF(20),NTF,NTR,NFA
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      COMMON/SOLDAX/ PHIFNT(07),THEFNT(07),
     1      PSIFNT(7),PHIRR(7),THERR(7),PSIRR(7)
      COMMON/ALPHA/ALPH(20)
      REAL*4 VHTPAR(27,7)
      INTEGER*4 PARMNO(27),NUMPRM/27/
      INTEGER*2 OPEN,RTSW,LDTSW,RBSW
         RBSW   = 0
         OPEN   = 0
      RTSW=1
      N1=295
      N2=119
 3333 FORMAT(20A4)
      READ(ICDRD,3333) (ALPH(I),I=1,20)
      READ(ICDRD, 900) (PHIFNT(I),I=1,7)
      READ(ICDRD, 900) (THEFNT(I),I=1,7)
      READ(ICDRD,900)  (PSIFNT(I),I=1,7)
      READ(ICDRD,900) (PHIRR(I),I=1,7)
      READ(ICDRD,900)  (THERR(I),I=1,7)
      READ(ICDRD,900) (PSIRR(I),I=1,7)
      NTF=1
  200 READ(ICDRD,900)   PBF(NTF),TQBF(NTF)
      IF(PBF(NTF).GE.99999.0) GO TO 210
      NTF=NTF+1
      GO TO 200
  210 NTF=NTF-1
      NTR=1
  220 READ(ICDRD,900)  PBR(NTR),TQBR(NTR)
      IF(PBR(NTR).GE.99999.0) GO TO 230
      NTR=NTR+1
      GO TO 220
  230 NTR=NTR-1
      NFA=1
  280 READ(ICDRD,900) GAMF(NFA),AFA(NFA)
      IF(GAMF(NFA).GE.99999.0) GO TO 290
      NFA=NFA+1
      GO TO 280
  290 NFA=NFA-1
      NCX=1
 240  READ(ICDRD,900)  TAU(NCX),CX(NCX)
      IF(TAU(NCX).GE.99999.) GO TO 241
      NCX=NCX+1
```

```
      GO TO 240                                                         USER 550
241   NCX= NCX-1                                                        USER 560
      NCY=1                                                             USER 570
242   READ(ICDRD,900) TAU(NCY),CY(NCY)                                  USER 580
      IF(TAU(NCY).GE.99999.) GO TO 243                                  USER 590
      NCY= NCY+1                                                        USER 600
      GO TO 242                                                         USER 610
243   NCY= NCY-1                                                        USER 620
      NCZ=1                                                             USER 630
244   READ(ICDRD,900) TAU(NCZ),CZ(NCZ)                                  USER 640
      IF(TAU(NCZ).GE.99999.) GO TO 245                                  USER 650
      NCZ= NCZ+1                                                        USER 660
      GO TO 244                                                         USER 670
245   NCZ= NCZ-1                                                        USER 680
      NCL=1                                                             USER 690
246   READ(ICDRD,900) TAU(NCL),CL(NCL)                                  USER 700
      IF(TAU(NCL).GE.99999.) GO TO 247                                  USER 710
      NCL=NCL+1                                                         USER 720
      GO TO 246                                                         USER 730
247   NCL= NCL-1                                                        USER 740
      NCM=1                                                             USER 750
248   READ(ICDRD,900) TAU(NCM),CM(NCM)                                  USER 760
      IF(TAU(NCM).GE.99999.) GO TO 249                                  USER 770
      NCM= NCM+1                                                        USER 780
      GO TO 248                                                         USER 790
249   NCM= NCM-1                                                        USER 800
      NCN=1                                                             USER 810
250   READ(ICDRD,900) TAU(NCN),CN(NCN)                                  USER 820
      IF(TAU(NCN).GE.99999.) GO TO 251                                  USER 830
      NCN= NCN+1                                                        USER 840
      GO TO 250                                                         USER 850
251   NCN= NCN-1                                                        USER 860
      NDCX=1                                                            USER 870
252   READ(ICDRD,900) ALPHA(NDCX),DELCX(NDCX)                           USER 880
      IF(ALPHA(NDCX).GE.99999.) GO TO 253                               USER 890
      NDCX= NDCX+1                                                      USER 900
      GO TO 252                                                         USER 910
253   NDCX =NDCX-1                                                      USER 920
      NDELF1 = 1
 300  READ(ICDRD,900) DELSF1(NDELF1) , FDLSF1(NDELF1)
      IF(DELSF1(NDELF1).GE.99999.) GO TO 310
      NDELF1 = NDELF1 + 1
      GO TO 300
 310  NDELF1 = NDELF1 - 1
      NDELF2 = 1
 301  READ(ICDRD,900) DELSF2(NDELF2) , FDLSF2(NDELF2)
      IF(DELSF2(NDELF2).GE.99999.) GO TO 311
      NDELF2 = NDELF2 + 1
      GO TO 301
 311  NDELF2 = NDELF2 - 1
      NDELR3 = 1
 302  READ(ICDRD,900) DELSR3(NDELR3) , FDLSR3(NDELR3)
      IF(DELSR3(NDELR3).GE.99999.) GO TO 312
      NDELR3 = NDELR3 + 1
      GO TO 302
 312  NDELR3 = NDELR3 - 1
      NDELR4 = 1
 303  READ(ICDRD,900) DELSR4(NDELR4) , FDLSR4(NDELR4)
      IF(DELSR4(NDELR4).GE.99999.) GO TO 313
      NDELR4 = NDELR4 + 1
```

```
      GO TO 303
  313 NDELR4 = NDELR4 - 1
      NWP=1
340   READ(ICDRD,900) XWP(NWP),VYWTB(NWP)
      IF(XWP(NWP).GE.99999.)GO TO 350
      NWP=NWP+1
      GO TO 340
350   NWP=NWP-1
  900 FORMAT(7E10.0)
      READ(ICDRD,100) (PARMNO(J),(VHTPAR(J,I),I=1,7),J=1,NUMPRM)
  100 FORMAT(I3,1X,7F10.3)
      ENTRY USERN2
      DO 1028 I=1,500
      READ(ICDRD,50,END=32) NOPARM,PARVAL
   50 FORMAT (I3,1X,G20.6)
      IF(NOPARM.EQ.304) GO TO 2222
 1100 PARAM(NOPARM)=PARVAL
 1028 CONTINUE
 32   WRITE(ITTY,33)
   33 FORMAT(' END OF CARDS')
 2222 CONTINUE
      RETURN
      END
```

2.1.4 VHTPIC

PRESENTED HERE IS THE FORTRAN LISTING FOR THE VHTP INITIALIZATION SUBPROGRAM. THE APPROPRIATE ELEMENTS OF THE PARAM ARRAY ARE INITIALIZED IN VHTPIC FOR PERFORMANCE OF THE SELECTED VHTP.

```
C     SUBROUTINE VHTPIC
      SUBROUTINE VHTPIC
C*****************************************************************************
C     THE APPROPRIATE ELEMENTS OF THE PARAM ARRAY ARE INITIALIZED IN
C     VHTPIC FOR PERFORMANCE OF THE SELECTED VHTP MANEUVER
C*****************************************************************************
      COMMON/VHTPDT/ PARMNO,VHTPAR
      COMMON/TABBS/ ITABP,ITABI,ITNAM,TABNUM
      COMMON/VHTPNM/ TABVAR,INDVAR,WRDVNT
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      COMMON/UNREAD/NAMEA,IWRDCT,INUMCT,LSTART,INDEXA,
     1 FNUMA,LAST,ILOP
      REAL*8 NAMEA(10)
      REAL*8 TABVAR(9,7)
      REAL*4 VHTPAR(27,7)
      INTEGER*4 INDEXA(10)
      INTEGER*4 PARMNO(27),SAVE/9/,NUMPRM/27/
      INTEGER*4 ITABI(9)
      INTEGER*4 ITABP(9),TABNUM,ITNAM(9)
      INTEGER*2 INDVAR(9,7)
      INTEGER*2 WRDVNT(9)
      IF(SAVE.EQ.PARAM(129)) GO TO 500
      I = IFIX(PARAM(129)) + 1
      IF(I.EQ.1) GO TO 10
      IF((I.GE.2).AND.(SAVE.NE.1)) GO TO 10
C     IF I = 1 ORIGINAL DATA MUST BE RESTORED
C     IF IIS NOT = 1 MUST DECIDE TO STORE DATA
C     IF I NE 1 AND OLD I NE 1 DO NOT STORE
      DO 20 J=1,NUMPRM
      VHTPAR(J,1) = PARAM(PARMNO(J))
   20 CONTINUE
   10 CONTINUE
      DO 30 J=1,NUMPRM
      PARAM(PARMNO(J)) = VHTPAR(J,I)
   30 CONTINUE
      IF(PARAM(129).EQ.4) PARAM(114)=PARAM(42)*((PARAM(6)+PARAM(7)))/60.
      IF(PARAM(129).EQ.5) PARAM(123)=66.*(PARAM(6)+PARAM(7))*PARAM(42)
     1 / (PARAM(66)*88.)
      IF(PARAM(129).EQ.6) PARAM(123)=PARAM(42)*(PARAM(6)+PARAM(7))
     1 / 7.5
C     SELECTS VARIABLES FOR TABLE OUTPUT
      I=IFIX(PARAM(129))
      IF(I.EQ.0) I=7
      TABNUM = WRDVNT(I)
      DO 40  J=1,TABNUM
      NAMEA(J) = TABVAR(J,I)
      INDEXA(J) = INDVAR(J,I)
   40 CONTINUE
      DO 100 I=1,TABNUM
      CALL FINDNM(K,J,I,&100)
      ITABI(I)=INDEXA(I)
      ITNAM(I)=J
      ITABP(I)=K
  100 CONTINUE
  500 CONTINUE
      SAVE = PARAM(129)
      RETURN
      END
```

2.1.5 NITIAL

PRESENTED HERE IS THE FORTRAN LISTING FOR THE INITIALIZATION SUBPROGRAM. THE FOLLOWING IS PERFORMED IN NITIAL:

1) Calculation of initial conditions using input data.

2) Initialization of digital-to-analog converters to their time = 0 values.

```
C     SUBROUTINE NITIAL
      SUBROUTINE NITIAL
C*****************************************************************************
C     THIS SUBPROGRAM CALCULATES INITIAL CONDITIONS USING INPUT DATA
C     AND INITIALIZES DIGITAL-TO-ANALOG CONVERTERS TO THEIR
C     TIME=O VALUES
C*****************************************************************************
      DIMENSION NAMEX(124),NAME(289)
      COMMON/DUALS/IDULTR,NWHEEL,TIRO2,TORO2,TIRTOR,VBRZRP,
     1 FXU5,FXU6,FYU5,FYU6,ALTQ5,ALTQ6,FSI3,FSI4,FSI5,FSI6,PPHIR
      COMMON/AERO/SFXS,SFYS,SFZS,SNTHES,SNPHIS,SNPSIS,APLUSB,IAERO
      COMMON/APL/ OPEN  ,RTSW  ,LDTSW ,RBSW
      COMMON/DEVICE/KEYBD,ITTY,ICDRD,LPTR,LPNT
      COMMON/SPLTAX/ SPSR3,SPSR4,IAX
      COMMON/HHHH/H1,H2,H3,H4
      COMMON/ZILCH/TQMAXF,TQMAXR,AKTQF,AKTQR,TQDRF,TQDRR,IDRSW
      COMMON/PTBK/AP1,AP2,AP3,AP4,AP5,BTC1,BTC2
      COMMON/CACATO/EPSK1,EPSK2,FEE1,FEE2,THE1,THE2
      COMMON/THINGS/TMAX1,TMAX2,TMAX3,TQRMAX,TQFMAX,PSIMAX,ONER
      COMMON/EES/O1,O2,O3,E4,E5,E6
      COMMON/ALPHA/ALPH(20)
      COMMON/COMBLK/AIXP,SM,AIYP,AIXZP,GAM1,GAM2,GAM3,AIXBR,AIYBR,
     1    AIZBR,A1,A2,AIXZBR,A12,E1,E2,E3,DELTA,GV1,GV2,GP1,GP2,GR1,
     1    GR2,CIP,CIVP,RZF,RZR,A2T,CA20,CA23,             ANGNL,ANGNLO
     1    ,TRO2,TFO2,TSO2,G,THRD,TWN7,R2T,RA20,RA23,ONEOA,ONEOD
     1,TSFO2
      COMMON/TIMBLK/JJTIME,TIME,DT
      COMMON/EFFS/ANUM,ADEN,ANUMDT,ADENDT,ANUMO,ADENO,ANUMDO,ADENDO,
     1  ANOUT,ADOUT
      COMMON/INOUT/ IN(32),DACO(48),ISW1,ISW7,IPRT
      COMMON/UVW/VC,UIN
      COMMON/XYZ/ NUMBR
      COMMON/OPSW/IHSW
      COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI,PO,QO,RO,UO,VO,WO,XO,
     1    YO,ZO,THEO,PHIO,PSIO
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      COMMON/XBS/XB(30),NS(4,30),DELX(4),XI(4),NNN
      COMMON/NONAME/XEND,O,EXIT2
      COMMON/NEWER/TIME25,TIME10,PSI5,PHIMAX,DSWMAX
      COMMON/COMVAR/ AXAVE,CUVRAT,BETDMX,CURTBP,TIMDEC,JUMP,DELSTR,DEL,
     1               AXI,CURVAV,ABBTV,AYMAX,RMAX,DELBET,DELPSI,BETAMX,
     1               TIMBMP,GETDL,TIMIN5,        TSTEP ,    IVHTP
      EQUIVALENCE
     1   (PARAM( 1),AMS)     , (PARAM( 2),AMUF)  , (PARAM( 3),AMUR)   ,
     1   (PARAM( 4),ZF)      , (PARAM( 5),ZR)    , (PARAM( 6),A)      ,
     1   (PARAM( 7),B)       , (PARAM( 8),TF)    , (PARAM( 9),TR)     ,
     1   (PARAM(10),TS)      , (PARAM(11),AIX)   , (PARAM(12),AIY)    ,
     1   (PARAM(13),AIZ)     , (PARAM(14),AIXZ)  , (PARAM(15),AIR)    ,
     1   (PARAM(16),CF)      , (PARAM(17),RF)    ,
     1   (PARAM(19),AKF1)    , (PARAM(20),AKF2)  , (PARAM(21),AKR3)   ,
     1   (PARAM(22),AKR4)    , (PARAM(23),CR)    , (PARAM(24),RR)     ,
     1   (PARAM(25),CF1P)    , (PARAM(26),CF2P)  , (PARAM(27),CR3P)   ,
     1   (PARAM(28),CR4P)                        , (PARAM(30),AKRS)   ,
     1   (PARAM(31),RW)                          , (PARAM(33),OT)     ,
     1   (PARAM(34),CA0)     , (PARAM(35),CA1)   , (PARAM(36),CA2)    ,
     1   (PARAM(37),CA3)     , (PARAM(38),CA4)   , (PARAM(39),TIR )   ,
     1   (PARAM(44),AKDL)    , (PARAM(41),AKSC)  , (PARAM(42),ANG)    ,
     1   (PARAM(43),WG)      , (PARAM(40),TOR )  , (PARAM(45),AKSL)
      EQUIVALENCE
```

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1    (PARAM(46),ANL1)    , (PARAM(47),AIPW)   , (PARAM(48),AIF)     ,  NITI 560
1    (PARAM(49),AIWF)    , (PARAM(50),AIWR)   , (PARAM(51),AID)     ,  NITI 570
1    (PARAM(52),ARBR)    , (PARAM(53),TSF )   , (PARAM(54),AKFS)    ,  NITI 580
1    (PARAM(55),PTBR)    , (PARAM(56),YSA1)   , (PARAM(57),YSA2)    ,  NITI 590
1    (PARAM(58),YHS1)    , (PARAM(59),YHS2)   , (PARAM(60),AKD)     ,  NITI 600
1    (PARAM(61), AIDF)   , (PARAM(62),ARFBR)  , (PARAM(63),PIN)     ,  NITI 610
1    (PARAM(64),QIN)     , (PARAM(65),RIN)    , (PARAM(66),UIZ)     ,  NITI 620
1    (PARAM(67),VIN)     , (PARAM(68),WIN)    , (PARAM(69),XIN)     ,  NITI 630
1    (PARAM(70),YIN)     , (PARAM(71),ZIN)    , (PARAM(72),THEIN)   ,  NITI 640
1    (PARAM(73),PHIIN)   , (PARAM(74),PSIIN)  , (PARAM(75),DTIN)    ,  NITI 650
1    (PARAM(76),TEND)    , (PARAM(77),AKT1)   , (PARAM(78),AKT2)   ,   NITI 660
1    (PARAM(79),AKT3)    , (PARAM(80),AKT4)   , (PARAM(81),RPS1)   ,   NITI 670
1    (PARAM(82),RPS2)    , (PARAM(83),RPS3)   , (PARAM(84),RPS4)    ,  NITI 680
1    (PARAM(85),B1)      , (PARAM(86),B2)     , (PARAM(87),B3)         NITI 690
 EQUIVALENCE                                                           NITI 700
1 (PARAM(88),B4),         (PARAM( 89),DEL1DN),(PARAM( 90),DEL2DN),     NITI 710
1  (PARAM( 91),DEL3DN),(PARAM( 92),DELFIN), (PARAM( 93),DELRIN),       NITI 720
1    (PARAM( 94),DEL3IN), (PARAM( 95),PHIDN), (PARAM(96),PHIRN),       NITI 730
1    (PARAM( 97),DFW1IN), (PARAM( 98),DFW2IN),(PARAM( 99),U1PIN),      NITI 740
1    (PARAM(100),U2PIN),   (PARAM(101),U3PIN), (PARAM(102),U4PIN),     NITI 750
1    (PARAM(103),S1PIN),   (PARAM(104),S2PIN), (PARAM(105),S3PIN),     NITI 760
1    (PARAM(106),S4PIN),  (PARAM(107),PPRT),(PARAM(109),RWSF)          NITI 770
1,(PARAM(110),TQMAX),(PARAM(111),AKTQ),(PARAM(112),VCIN)               NITI 780
1,(PARAM(113),SWMT),(PARAM(114),DSWCM),(PARAM(115),TST),               NITI 790
1(PARAM(116),DSLP),(PARAM(117),CGAM),(PARAM(118),CS)                   NITI 800
1   ,(PARAM(119),TQRBR),(PARAM(120),TQFBR)                             NITI 810
1   ,(PARAM(121),PFL),(PARAM(122),TTD),(PARAM(123),DSW)                NITI 820
1    ,(PARAM(124),TSW)                                                 NITI 830
 EQUIVALENCE                                                           NITI 840
1  (PARAM(130),AMCR),(PARAM(131),ESP),(PARAM(132),AKSL1),              NITI 850
1  (PARAM(133),AKSL2),(PARAM(134),AA1),(PARAM(135),AA2),               NITI 860
1  (PARAM(136),CCR),(PARAM(137),CFCR),(PARAM(138),AP),                 NITI 870
1  (PARAM(139),EP1),(PARAM(140),EP2),(PARAM(141),ERR1),                NITI 880
1  (PARAM(142),ERR2),                                                  NITI 890
1  (PARAM(143),AML1),(PARAM(144),AML2),(PARAM(145),RRIM),              NITI 900
1    (PARAM(146),RWR)                                                  NITI 910
 EQUIVALENCE                                                           NITI 920
1    (PARAM(284),HFC),(PARAM(285),HRC)                                 NITI 930
 EQUIVALENCE                                                           NITI 940
1    (PARAM(290),ROT),(PARAM(291),RA0),(PARAM(292),RA1),               NITI 950
1    (PARAM(293),RA2),(PARAM(294),RA3),(PARAM(295),RA4)                NITI 960
 EQUIVALENCE                                                           NITI 970
1(PARAM(296),DEL1DT),(PARAM(297),DEL2DT),(PARAM(298),DEL3DT),          NITI 980
1(PARAM(299),DEL1),(PARAM(300),DEL2),(PARAM(301),DEL3),                NITI 990
1(PARAM(302),PHIRD),(PARAM(303),PHIR),(PARAM(304),DELFW1),             NITI1000
1(PARAM(305),DELFW2),(PARAM(306),U1P),(PARAM(307),U2P),                NITI1010
1(PARAM(308),U3P),(PARAM(309),U4P),(PARAM(310),S1P),                   NITI1020
1(PARAM(311),S2P),(PARAM(312),S3P),(PARAM(313),S4P),                   NITI1030
1(PARAM(314),QUAN1),(PARAM(315),QUAN2),(PARAM(316),QUAN3),             NITI1040
1(PARAM(317),QUAN4),(PARAM(318),ARPS3),(PARAM(319),ARPS4),             NITI1050
1(PARAM(320),RWZ1A),(PARAM(321),RWZ2A),(PARAM(322),RWZ3A),
1(PARAM(323),RWZ4A),(PARAM(324),IOUT(1))
 EQUIVALENCE (NAME(172),NAMEX(1))                                      NITI1080
 EQUIVALENCE (PHIFD,DEL2DT),(PHIF,DEL2)                                NITI1090
 EQUIVALENCE (PHIRD,DEL4DT),(PHIR,DEL4)                                NITI1100
 DATA NAME/' MS',' MUF',' MUR',' ZF',' ZR','  A','  B',' TF',NITI1110
1    ' TR',' TSR',' IX',' IY',' IZ',' IXZ',' IR','   ',' RF',NITI1120
1    'STOP','AKF1','AKF2','AKR3','AKR4','    ',' RR','CF1P','CF2P',NITI1130
1    'CR3P','CR4P','ZBAS',' KRS',' RW','SCAL',' FOT',' A0',' A1',NITI1140
1    ' A2',' A3',' A4','TIR ','TOR ',' KSC',' NG','    ','    ',NITI1150
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     1   '    ','    ',' IFW',' IF ',' IWF',' IWR',' IDR',' ARR','TSF ',
     1   'KFS ','  PT','YSA1','YSA2','PHS1','PHS2','CTSW',' IDF',' ARF',
     1   'P-IN','Q-IN','R-IN','U-IN','V-IN','W-IN','X-IN','Y-IN','Z-IN',
     1   'THIN','PHIN','PSIN','  DT','  TN',' KT1',' KT2',' KT3',' KT4',
     1   'RPS1','RPS2','RPS3','RPS4','  B1','  B2','  B3','  B4','D1DT',
     1   'D2DT','D3DT','DELF','DELR','DEL3','PHDT','PHIR','DFW1','DFW2',
     1   'U1PR','U2PR','U3PR','U4PR','S1PR','S2PR','S3PR','S4PR','PPRT',
     1   'FREQ','RWSF','TQMX',' KTQ','  VC','MTSW','DSWM',' TST','DSLP',
     1   'CGAM','  CS',' TQR',' TQF',' PFL','  T1',' DSW','    ','ISW5',
     1   'SW15',
     1   'PQSW','VTPS','VHTP','AMCR',' ESP','KSL1','KSL2',' AA1',' AA2',
     1   ' CCR','CFCR','  AP',' EP1',' EP2','AERO','VYW ','OMXW','OMZW',
     1   'RHOA','CYP ','CYR ','CZAL','CZQ ','CLP ','CLR ','CMAL','CMQ ',
     1   'CNP ','CNR ','SF  ','VLEN','REWV','    ','    ','    ','    ',
     1   '    ','    ','    ','    ','    ','    ',' SNT','SNSO','SNS1'/
      DATA NAMEX
     1  /'SNSW','DIST',' PL ','TSCP','    ','    ','    ','    ','PASS',
     1   '    ',' SI1',' SI2',' SI3',' SI4','    ','    ','    ',
     1   '    ','    ','    ','MTQB','DCSW',' LDF','LDRF',' EK1',' EK2',
     1   'BMPL','BMPS','BMPH','  XB','APF1','APF2','APR1','APR2','MUSF',
     1   'MUSR','BCON','FCSW','    ','    ','    ','    ','    ','    ',
     1   '    ','    ','    ','FEE1','FEE2','THE1','THE2','    ','    ',
     1   '    ','    ','    ','    ','    ','    ','    ','  H1','  H2','LAMD',
     1   '    ','    ','    ','    ','    ',' BR1',' BR2',' BR3',' BR4',
     1   ' KCF',' KCR',' KSR',' RB1',' RB2',' RB3',' RB4','AFK1','AFK2',
     1   'AFK3','ARK1','ARK2','ARK3','OFC0','OFC1','OFC2','OFC3','ORC0',
     1   'ORC1','ORC2','ORC3','CP0F','CP1F','CP2F','CP0R','CP1R','CP2R',
     1   'CR0F','CR1F','CR2F','CR0R','CR1R','CR2R','    ','    ','BMPN',
     1   'TQB0','TQB1','    ','    ','    ','    ',' HFC',' HRC','DRSW',
     1   'AXLE','DUAL','TIRE','ROT','RA0','RA1','RA2','RA3','RA4'/
      EQUIVALENCE (COMPVR(1),AXAVE)
      DIMENSION COMPVR(17)
      DATA RAD/0.1745329E-1/
      DATA MPHIPS/17.6/
      REAL*4 MPHIPS
      REAL*4 IOUT(48),IN,     SCALAC(28),SCALDC(48)
      INTEGER*2   RTSW  ,RBSW  ,LITSW ,OPEN  ,OPDN
  960 FORMAT('1  PARAMETER VALUES - MODEL C - ',20A4,/
     1   (' ',5(I4,3X,A4,'=',G12.5,',')))
C     VHTP COMPARISON VARIABLE INITIALIZATION
      DO 21 I=1,19
      COMPVR(I) = 0.
   21 CONTINUE
      TSTEP = DTIN
      NUMBR = 0
      DO 20 I=1,4
      DELX(I) = 0.
   20 CONTINUE
      IVHTP = PARAM(129) + .5
      IAERO = PARAM(141) + 0.5
      IDRSW = PARAM(286) + 0.5
      IAX=PARAM(287)+0.5
C     DUAL TIRES ON SOLID REAR AXLE
C                  IDULTR = 0, NO DUALS
C                         = 1, DUALS
      IDULTR = PARAM(288) + 0.5
C     NWHEEL = 4, SINGLE REAR TIRES
C            = 6, DUAL REAR TIRES
C            = 10, DOUBLE DUAL REAR TIRES
      NWHEEL = PARAM(289) + 0.5
```

```
      TQFMAX=-1.E20                                                     NITI1760
      TQRMAX=-1.E20                                                     NITI1770
      AP1=PARAM(055)                                                    NITI1780
      AP2=PARAM(213)                                                    NITI1790
      AP3=PARAM(214)                                                    NITI1800
      AP4=PARAM(215)                                                    NITI1810
      AP5=PARAM(216)                                                    NITI1820
      BTC1=PARAM(217)                                                   NITI1830
      BTVMAX=-1.E20                                                     NITI1840
      BTC2=PARAM(218)                                                   NITI1850
      EPSK1=PARAM(196)*RAD                                              NITI1860
      EPSK2=PARAM(197)*RAD                                              NITI1870
      FEE1=PARAM(219)*RAD                                               NITI1880
      FEE2=PARAM(220)*RAD                                               NITI1890
      THE1=PARAM(221)*RAD                                               NITI1900
      THE2=PARAM(222)*RAD                                               NITI1910
      PSIMAX=-1.E20                                                     NITI1920
      PSIM=PSIIN*RAD                                                    NITI1930
      XEND=TEND                                                         NITI1940
      EXIT2 = PARAM(18)*MPHIPS
      TIME25=0.0                                                        NITI1960
      TIME10=0.0                                                        NITI1970
      O1=-6.0E-6                                                        NITI1980
      O2=0.009                                                          NITI1990
      O3=0.0001                                                         NITI2000
      E4=-0.16                                                          NITI2010
      E5=-0.46                                                          NITI2020
      E6=10.4                                                           NITI2030
      ANUMO=0.0                                                         NITI2040
      ADENO=0.0                                                         NITI2050
      RMAX=-1.E20                                                       NITI2060
      PSI5=0.0                                                          NITI2070
      DSWMAX=-1.E20                                                     NITI2080
      PHIMAX=-1.E20                                                     NITI2090
      ETAMAX=-1.E20                                                     NITI2100
      ISW7=1                                                            NITI2110
      THRD=1.0/3.0                                                      NITI2120
      TWN7=1.0/27.0                                                     NITI2130
      TOO=0.0                                                           NITI2140
      G=386.4                                                           NITI2150
      APLUSB = A + B                                                    NITI2160
      H1=RW-(AMUF+B*AMS/(A+B))*G/(2.*AKT1)                              NITI2170
      H2=RW-(AMUF+B*AMS/(A+B))*G/(2.*AKT2)                              NITI2180
      H3=RW-(AMUR+A*AMS/(A+B))*G/(2.*AKT3)                              NITI2190
      H4=RW-(AMUR+A*AMS/(A+B))*G/(2.*AKT4)                              NITI2200
      IF(IDULTR.NE.1) GO TO 25                                          NITI2210
      H3 = RW - (AMUR+A*AMS /(A+B))*G/(4.*AKT3)                         NITI2220
      H4 = H3                                                           NITI2230
   25 CONTINUE                                                          NITI2240
       RWZ1A = RW - H1
       RWZ2A = RW - H2
       RWZ3A = RW - H3
       RWZ4A = RW - H4
      TSO2=TS/2.0                                                       NITI2250
      TSFO2 = TSF/2.                                                    NITI2260
      TFO2=TF*0.5                                                       NITI2270
      TIRO2 = TIR/2.                                                    NITI2280
      TORO2 = TOR/2.                                                    NITI2290
      TRO2=TR*0.5                                                       NITI2300
      IF(IDULTR.EQ.1) TRO2 = (TORO2+TIRO2)*0.5                          NITI2310
```

```
      TIRTOR= 0.25*(TIR-TCR)                                              NITI2320
      SPSR3=(TAN(2.0*HFC/TF))*2.0/AMUF                                    NITI2330
      SPSR4=(TAN(2.0*HRC/TR))*2.0/AMUR                                    NITI2340
      SM=AMS+AMUF+AMUR                                                    NITI2350
      UIN=UIZ*MPHIPS                                                      NITI2360
      VC=VCIN*MPHIPS                                                      NITI2370
      ZIN=(B*(H1+ZF)+A*(H3+ZR))/(A+B)*(-1.)  + PARAM(29)
      THEIN=(H1-H3+ZF-ZR)/(A+B)/RAD                                       NITI2390
      ARPS3 = UIN/H3                                                      NITI2400
      ARPS4 = UIN/H4                                                      NITI2410
      AIXP=AMUF*ZF*ZF+AMUR*ZR*ZR                                          NITI2420
      AIYP=AIXP                                                           NITI2430
      GO TO (31,32),IAX                                                   NITI2440
   30 AIZP = AMUF*A*A + AMUR*B*B + AIF + AIR                              NITI2450
      GO TO 33                                                            NITI2460
   31 AIZP = AMUF*(A*A + TFO2**2) + AMUR*B*B + AIR                        NITI2470
      GO TO 33                                                            NITI2480
   32 AIZP = AMUF*(A*A + TFO2**2) + AMUR*(B*B + TRO2**2)                  NITI2490
   33 CONTINUE                                                            NITI2500
      AIXZP=AMUF*A*ZF-AMUR*B*ZR                                           NITI2510
      GAM1=AMUF*A-AMUR*B                                                  NITI2520
      GAM2=AMUF*ZF+AMUR*ZR                                                NITI2530
      GAM3=GAM2                                                           NITI2540
      AIXBR=AIX+AIXP                                                      NITI2550
      AIYBR=AIY+AIYP                                                      NITI2560
      AIZBR=AIZP +AIZ                                                     NITI2570
      AIXZBR=AIXZP+AIXZ                                                   NITI2580
      E1=AIXBR*AIZBR-AIXZBR**2                                            NITI2590
      E2=GAM1*AIXZBR-GAM3*AIZBR                                           NITI2600
      E3=GAM3*AIXZBR-GAM1*AIXBR                                           NITI2610
      GV1=GAM2*AIZBR-GAM1*AIXZBR                                          NITI2620
      GV2=GAM2*AIXZBR-GAM1*AIXBR                                          NITI2630
      GP1=SM*AIZBR-GAM1**2                                                NITI2640
      GP2=SM*AIXZBR-GAM1*GAM3                                             NITI2650
      GR1=GP2                                                             NITI2660
      GR2=SM*AIXBR-GAM2*GAM3                                              NITI2670
      CIP=B*AMS*G/(AMUF*(A+B))+G                                          NITI2680
      CIVP=A*AMS*G/(AMUR*(A+B))+G                                         NITI2690
      TQMAXR=TQMAX*ARBR*0.5                                               NITI2700
      TQMAXF=TQMAX*ARFBR*0.5                                              NITI2710
      AKTQR=AKTQ*ARBR*0.5                                                 NITI2720
      AKTQF=AKTQ*ARFBR*0.5                                                NITI2730
      RZF=RW+ZF                                                           NITI2740
      RZR=RW+ZR                                                           NITI2750
      CA23=CA2*CA3                                                        NITI2760
      A2T= OT*CA2                                                         NITI2770
      CA20=CA0*CA2                                                        NITI2780
      RA23=RA2*RA3                                                        NITI2790
      R2T=ROT*RA2                                                         NITI2800
      RA20=RA0*RA2                                                        NITI2810
      A1=GAM2/SM                                                          NITI2820
      A2=AIYBR/GAM2                                                       NITI2830
      A12=A1-A2                                                           NITI2840
      ONEOA=1.0/A12                                                       NITI2850
      DELTA=E1*SM+GAM2*E2+GAM1*E3                                         NITI2860
      ONEOD=1.0/DELTA                                                     NITI2870
      DEL1DT=DEL1DN                                                       NITI2880
      DEL2DT=DEL2DN                                                       NITI2890
      DEL3DT=DEL3DN                                                       NITI2900
      DEL1=0.0                                                            NITI2910
```

```
      DEL2=0.0
      DEL3=DEL3IN
      PHIRD=PHIDN*RAD
      PHIR=PHIRN*RAD
      DELFW1=DFW1IN*RAD
      DELFW2=DFW2IN*RAD
      U1P=U1PIN
      U2P=U2PIN
      U3P=U3PIN
      U4P=U4PIN
      S1P=S1PIN
      S2P=S2PIN
      S3P=S3PIN
      S4P=S4PIN
      QUAN1=0.0
      QUAN2=0.0
      QUAN3=0.0
      QUAN4=0.0
      P=PIN*RAD
      PO=P
      Q=QIN*RAD
      QO=Q
      R=RIN*RAD
      RO=R
      U=UIN
      UO=U
      V=VIN
      VO=VIN
      W=WIN
      WO=WIN
      X=XIN
      XO=XIN
      Y=YIN
      YO=YIN
      Z=ZIN
      ZO=ZIN
      THE=THEIN*RAD
      THEO=THE
      PHI=PHIIN*RAD
      PHIO=PHI
      PSI=PSIIN*RAD
      PSIO=PSI
      TIME=0.0
      JJTIME=0
      DT=0.0
  998 FORMAT('0',8E15.6)
      IHSW=0
      XB(1)=PARAM(201)
      NBMP=PARAM(277)+0.5
      IF(NBMP.LT.2) GO TO 4321
      DO 5432 I=2,NBMP
      XB(I)=XB(I-1)+PARAM(199)
 5432 CONTINUE
 4321 CONTINUE
             CALL SSRM(11,IRLERR)
      RETURN
      ENTRY NTIAL1
      CALL LBDAFP(00,47,DACO,ILBERR)
      CALL TLDA
      CALL STCO(1,ISTCOE)
```

```
      DT=DTIN
      ISW1=0
      ISW7=0
      IF(PPRT.NE.0.0) WRITE(LPTR,960) (ALPH(I),I=1,20),((K,NAME(K),
     1 PARAM(K)),K=1,N1)
  940 FORMAT(10G12.5)
      RETURN
      END
```

2.1.6 POTSET

PRESENTED HERE IS THE FORTRAN LISTING FOR THE POTENTIOMETER SETTING CALCULATION SUBPROGRAM. THE FOLLOWING IS PERFORMED IN POTSET:

1) Calculation of parameters used in the potentiometer equations.

2) Calculation of potentiometer settings.

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C     SUBROUTINE POTSET                                                 POTS  10
      SUBROUTINE POTSET                                                 POTS  20
C***********************************************************************
C     THIS SUBPROGRAM CALCULATES PARAMETERS USED IN THE POTENTIOMETER
C     EQUATIONS AND POTENTIOMETER SETTINGS
C***********************************************************************
      COMMON/DUALS/IDULTR,NWHEEL,TIRO2,TORO2,TIRTOR,VBRZRP,             POTS  40
     1 FXU5,FXU6,FYU5,FYU6,ALTQ5,ALTQ6,FSI3,FSI4,FSI5,FSI6,PPHIR        POTS  50
      COMMON/ZILCH/TQMAXF,TQMAXR,AKTQF,AKTQR,TQDRF,TQDRR,IDRSW          POTS  60
      COMMON/DEVICE/KEYBD,ITTY,ICDRD,IPTR,LPNT                          POTS  70
      COMMON/HHHH/H1,H2,H3,H4                                           POTS  80
      COMMON/SPLTAX/ SPSR3,SPSR4,IAX                                    POTS  90
      COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI,PO,QO,RO,UO,VO,WO,XO,   POTS 100
     1    YO,ZO,THEO,PHIO,PSIO                                          POTS 110
      COMMON/EFFS/ANUM,ADEN,ANUMDT,ADENDT,ANUMO,ADENO,ANUMDO,ADENDO,    POTS 120
     1   ANOUT,ADOUT                                                    POTS 130
      COMMON/COMBLK/AIXP,SM,AIYP,AIXZP,GAM1,GAM2,GAM3,AIXBR,AIYBR,      POTS 140
     1    AIZBR,A1,A2,AIXZBR,A12,E1,E2,E3,DELTA,GV1,GV2,GP1,GP2,GR1,    POTS 150
     1    GR2,CIP,CIVP,RZF,RZR,A2T,CA20,CA23,            ANGNL,ANGNLO   POTS 160
     1    ,TRO2,TFO2,TSO2,G,THRD,TWN7,R2T,RA20,RA23,ONEOA,ONEOD         POTS 170
     1,TSFO2                                                            POTS 180
      COMMON/TIMBLK/JJTIME,TIME,DT                                      POTS 190
      COMMON/UVW/VC,UIN                                                 POTS 200
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)              POTS 210
      REAL*4 IOUT(48)                                                   POTS 220
      REAL*4 IPOT,IPOTAD                                                POTS 230
      EQUIVALENCE                                                       POTS 240
     1   (PARAM( 1),AMS)    , (PARAM( 2),AMUF)  , (PARAM( 3),AMUR)    , POTS 250
     1   (PARAM( 4),ZF)     , (PARAM( 5),ZR)    , (PARAM( 6),A)       , POTS 260
     1   (PARAM( 7),B)      , (PARAM( 8),TF)    , (PARAM( 9),TR)      , POTS 270
     1   (PARAM(10),TS)     , (PARAM(11),AIX)   , (PARAM(12),AIY)     , POTS 280
     1   (PARAM(13),AIZ)    , (PARAM(14),AIXZ)  , (PARAM(15),AIR)     , POTS 290
     1   (PARAM(16),CF)     , (PARAM(17),RF)    ,                       POTS 300
     1   (PARAM(19),AKF1)   , (PARAM(20),AKF2)  , (PARAM(21),AKR3)    , MODE 890
     1   (PARAM(22),AKR4)   , (PARAM(23),CR)    , (PARAM(24),RR)      , MODE 910
     1   (PARAM(25),CF1P)   , (PARAM(26),CF2P)  , (PARAM(27),CR3P)    , MODE 900
     1   (PARAM(28),CR4P)                       , (PARAM(30),AKRS)    , MODE 920
     1   (PARAM(31),RW)                         , (PARAM(33),OT)      , POTS 350
     1   (PARAM(34),CA0)    , (PARAM(35),CA1)   , (PARAM(36),CA2)     , POTS 360
     1   (PARAM(37),CA3)    , (PARAM(38),CA4)   , (PARAM(39),TIR )    , POTS 370
     1   (PARAM(44),AKDL)   , (PARAM(41),AKSC)  , (PARAM(42),ANG)     , POTS 380
     1   (PARAM(43),WG)     , (PARAM(40),TOR )  , (PARAM(45),AKSL)      POTS 390
      EQUIVALENCE                                                       POTS 400
     1   (PARAM(46),ANL1)   , (PARAM(47),AIFW)  , (PARAM(48),AIF)     , POTS 410
     1   (PARAM(49),AIWF)   , (PARAM(50),AIWR)  , (PARAM(51),AID)     , POTS 420
     1   (PARAM(52),ARBR)   , (PARAM(53),TSF )  , (PARAM(54),AKFS)    , POTS 430
     1   (PARAM(55),PTBR)   , (PARAM(56),YSA1)  , (PARAM(57),YSA2)    , POTS 440
     1   (PARAM(58),YHS1)   , (PARAM(59),YHS2)  , (PARAM(60),AKD)     , POTS 450
     1   (PARAM(61), AIDF)  , (PARAM(62),ARFBR) , (PARAM(63),PIN)     , POTS 460
     1   (PARAM(64),QIN)    , (PARAM(65),RIN)   , (PARAM(66),UIZ)     , POTS 470
     1   (PARAM(67),VIN)    , (PARAM(68),WIN)   , (PARAM(69),XIN)     , POTS 480
     1   (PARAM(70),YIN)    , (PARAM(71),ZIN)   , (PARAM(72),THEIN)   , POTS 490
     1   (PARAM(73),PHIIN)  , (PARAM(74),PSIIN) , (PARAM(75),DTIN)    , POTS 500
     1   (PARAM(76),TEND)   , (PARAM(77),AKT1)  , (PARAM(78),AKT2)   ,  POTS 510
     1   (PARAM(79),AKT3)   , (PARAM(80),AKT4)  , (PARAM(81),RPS1)   ,  POTS 520
     1   (PARAM(82),RPS2)   , (PARAM(83),RPS3)  , (PARAM(84),RPS4)    , POTS 530
     1   (PARAM(85),B1)     , (PARAM(86),B2)    , (PARAM(87),B3)        POTS 540
      EQUIVALENCE                                                       POTS 550
     1 (PARAM(88),B4),        (PARAM( 89),DEL1DN),(PARAM( 90),DEL2DN),  POTS 560
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```
1  (PARAM( 91),DEL3DN),(PARAM( 92),DELFIN), (PARAM( 93),DELRIN),     POTS 570
1   (PARAM( 94),DEL3IN), (PARAM( 95),PHIDN), (PARAM(96),PHIRN),      POTS 580
1   (PARAM( 97),DFW1IN), (PARAM( 98),DFW2IN),(PARAM( 99),U1PIN),     POTS 590
1   (PARAM(100),U2PIN),   (PARAM(101),U3PIN), (PARAM(102),U4PIN),    POTS 600
1   (PARAM(103),S1PIN),   (PARAM(104),S2PIN), (PARAM(105),S3PIN),    POTS 610
1   (PARAM(106),S4PIN), (PARAM(107),PPRT),(PARAM(109),RWSF)          POTS 620
1,(PARAM(110),TQMAX),(PARAM(111),AKTQ),(PARAM(112),VCIN)             POTS 630
1,(PARAM(113),SWMT),(PARAM(114),DSWCM),(PARAM(115),TST),             POTS 640
1(PARAM(116),DSLP),(PARAM(117),CGAM),(PARAM(118),CS)                 POTS 650
1  ,(PARAM(119),TQRBR),(PARAM(120),TQFBR)                            POTS 660
1  ,(PARAM(121),PFL),(PARAM(122),TTD),(PARAM(123),DSW)               POTS 670
1   ,(PARAM(124),TSW)                                                POTS 680
 EQUIVALENCE                                                         POTS 690
1  (PARAM(130),AMCR),(PARAM(131),ESP),(PARAM(132),AKSL1),            POTS 700
1  (PARAM(133),AKSL2),(PARAM(134),AA1),(PARAM(135),AA2),             POTS 710
1  (PARAM(136),CCR),(PARAM(137),CFCR),(PARAM(138),AP),               POTS 720
1  (PARAM(139),EP1),(PARAM(140),EP2),(PARAM(141),ERR1),              POTS 730
1  (PARAM(142),ERR2),                                                POTS 740
1  (PARAM(143),AML1),(PARAM(144),AMI2),(PARAM(145),RRIM),            POTS 750
1   (PARAM(146),RWR)                                                 POTS 760
 EQUIVALENCE                                                         POTS 770
1   (PARAM(223),CR1C),(PARAM(224),CR1T),(PARAM(225),CR2C),           POTS 780
1   (PARAM(226),CR2T),(PARAM(227),CR3C),(PARAM(228),CR3T),           POTS 790
1   (PARAM(229),CR4C),(PARAM(230),CR4T),(PARAM(231),AH1),            POTS 800
1   (PARAM(232),AH2),(PARAM(233),ALAMBD)
 EQUIVALENCE                                                         POTS 830
1   (PARAM(284),HFC),(PARAM(285),HRC)                                POTS 840
 EQUIVALENCE                                                         POTS 850
1   (PARAM(290),ROT),(PARAM(291),RA0),(PARAM(292),RA1),              POTS 860
1   (PARAM(293),RA2),(PARAM(294),RA3),(PARAM(295),RA4)               POTS 870
 EQUIVALENCE                                                         POTS 880
1(PARAM(296),DEL1DT),(PARAM(297),DEL2DT),(PARAM(298),DEL3DT),        POTS 890
1(PARAM(299),DEL1),(PARAM(300),DEL2),(PARAM(301),DEL3),              POTS 900
1(PARAM(302),PHIRD),(PARAM(303),PHIR),(PARAM(304),DELFW1),           POTS 910
1(PARAM(305),DELFW2),(PARAM(306),U1P),(PARAM(307),U2P),              POTS 920
1(PARAM(308),U3P),(PARAM(309),U4P),(PARAM(310),S1P),                 POTS 930
1(PARAM(311),S2P),(PARAM(312),S3P),(PARAM(313),S4P),                 POTS 940
1(PARAM(314),QUAN1),(PARAM(315),QUAN2),(PARAM(316),QUAN3),           POTS 950
1(PARAM(317),QUAN4),(PARAM(318),ARPS1),(PARAM(319),ARPS2),           POTS 960
1(PARAM(320),WSTH1),(PARAM(321),WCTH1),(PARAM(322),WSTH2),           POTS 970
1(PARAM(323),WCTH2),(PARAM(324),IOUT(1))                             POTS 980
 DATA T/1./                                                          POTS 990
C       N1 , N2 EQUATED TO THEIR VALUES IN MAIN                      POTS1000
 HUN=0.01                                                            POTS1010
 TOU=0.001                                                           POTS1020
 AIBR=AIWR+AID*ARBR**2*0.25                                          POTS1030
 AIBRP=AIBR-AIWR                                                     POTS1040
 AIFBR = AIWF + AIDF*ARFBR*2 * 0.25                                  POTS1050
 AIFBRP = AIFBR - AIWF                                               POTS1060
 RPS1=UIN/H1                                                         POTS1070
 RPS2=UIN/H2                                                         POTS1080
 RPS3=UIN/H3                                                         POTS1090
 RPS4=UIN/H4                                                         POTS1100
 CALL SSRM(01,IRLERR)                                                POTS1880
 IF(RF.GE.0) CALL SSRP(01,IRLERR)                                    POTS1890
 CALL SSRM(08,IRLERR)                                                POTS1920
 IF(RR.GE.0) CALL SSRP(08,IRLERR)
 SPSF=PARAM(32)/10000.
 IPOT(16 )= TOU*CF1P*T
 IPOT(19 )= .2*TOU*CF1P*T
```

```
      IPOT(22 )= TOU*CF2P*T
      IPOT(24 )= .2*TOU*CF2P*T
      IPOT(27 )= TOU*CR3P*T
      IPOT(29 )= .2*TOU*CR3P*T
      IPOT(49 )= TOU*CR4P*T
      IPOT(050)=AIBRP/AIBR*T
      IPOT(51)=((RWSF*4.*AKT1)/(10000.*AIWF))*T*0.1
      IPOT(52 )=(4.0/AIWF)*T*PARAM(238)
      IPOT(54 )= .2*TOU*CR4P*T
      IPOT(55)=(100.*RWSF/3000.)*T                                      POTS1370
      IPOT(56)=IPOT(55)                                                 POTS1380
      IPOT(58)=IPOT(55)                                                 POTS1390
      IPOT(60) =100.*T/AKF1
      IPOT(61) =100.*T/AKF2
      IPOT(62) =100.*T/AKR3
      IPOT(63) =100.*T/AKR4
      IPOT(64)=SFSF
      IPOT(65)=SFSF
      IPOT(68)=SFSF
      IPOT(69)=SFSF
      IPOT(72)=IPOT(55)                                                 POTS1440
      IPOT(073)=T*PARAM(175)
      IPOT(83)=((RWSF*4.*AKT4)/(10000.*AIBR))*T*0.1
      IPOT(085)=T*PARAM(175)
      IPOT(086)=0.2000*T                                                POTS1460
      IPOT(87)=(2./RWSF)*T                                              POTS1470
      IPOT(88)=(RW/RWSF)*T                                              POTS1480
      IPOT(90) = 0.0                                                    POTS1820
      IPOT(91) = 0.0                                                    POTS1830
      IPOT(096)=IPOT(86)
      IPOT(98 )=IPOT(88 )                                               POTS1500
      IPOT(100)=T*PARAM(175)
      IPOT(99 )=IPOT(87 )                                               POTS1510
      IPOT(101)=HUN*RPS1*T                                              POTS1520
      IPOT(102)=((RWSF*4.*AKT2)/(10000.*AIWF))*T*0.1
      IPOT(103)=(4.0/AIWF)*T*PARAM(239)
      IPOT(104)=HUN*RPS2*T                                              POTS1550
      IPOT(105)=T*PARAM(175)
      IPOT(106)=IPOT(86)
      IPOT(107)=IPOT(87 )                                               POTS1570
      IPOT(108)=IPOT(88 )                                               POTS1580
      IPOT(110)=HUN*RPS3*T                                              POTS1590
      IPOT(111)=(4.0/AIBR)*T*PARAM(241)
      IPOT(112)=(4.0/AIBR)*T*PARAM(240)
      IPOT(113)=((RWSF*4.*AKT3)/(10000.*AIBR))*T*0.1
      IPOT(114)=HUN*RPS4*T                                              POTS1630
      IPOT(116)=IPOT(86)
      IPOT(117)=IPOT(87 )                                               POTS1650
      IPOT(118)=IPOT(88 )                                               POTS1660
      IPOT(119)=IPOT(50)
C###############################################
C### SPLIT FRONT AXLE LOGIC FOR 680      #####
C###############################################
             CALL SSRM(00,IRLERR)                                       POTS1860
      IPOT(01 )=T*PARAM(175)/AMS  * SFSF * 10.
      IPOT(02 )=(2.0/      (AMUF))*T*PARAM(175)  * SFSF
      IPOT(04 )=(HUN*RF/(TF*TF))*T*0.1                                  POTS1140
      IPOT(05)=(2.0*AKT2/(5000.0*AMUF))*T/1.0*PARAM(175)                POTS1150
      IPOT(06 )=T*PARAM(175)/AMS * SFSF * 10.
      IPOT(07 )=IPOT(02 )                                               POTS1170
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```
      IPOT(21)=PARAM(175)*T                                            POTS1250
      IPOT(25)=PARAM(175)*T                                            POTS1280
      IPOT(32)=(2.0*AKT1/(5000.0*AMUF))*T/1.0*PARAM(175)               POTS1320
      IPOT(03) = 0.0                                                   POTS1730
      IPOT(08) = 0.0                                                   POTS1740
      IPOT(34) = 0.0                                                   POTS1750
      IPOT(39) = 0.0                                                   POTS1760
      IPOT(44) = 0.0                                                   POTS1770
      IPOT(47) = 0.0                                                   POTS1780
      IPOT(59) = 0.0                                                   POTS1790
      IPOT(66) = 0.0                                                   POTS1800
      IPOT(67) = 0.0                                                   POTS1810
      IPOT(95) = 0.0                                                   POTS1840
      IPOT(97) = 0.0                                                   POTS1850
      IF(IAX.NE.0) GO TO 1024                                          POTS1940
C############################################                          POTS1950
C### SOLID FRONT AXLE LOGIC FOR 680      #####                          POTS1960
C############################################                          POTS1970
            CALL SSRP(00,IRLERR)                                       POTS1980
      IPOT(02 )=(1.0/(      AMUF))*T*PARAM(175)  * SFSF
      IPOT(03) = TF/80.* T                                             POTS2050
      IPOT(08) = 20.*TSF/(2.*AIF)*T*PARAM(175)  * SFSF* 10.
      IPOT(25) = (1./2.5)*T*PARAM(175)                                 POTS2070
      IPOT(32)=(2.0*AKT1/(10000.*AMUF))*T/1.0*PARAM(175)               POTS2080
      IPOT(34) = IPOT(02)                                              POTS2090
      IPOT(39)=0.25*(ABS(RF))/(10000.*TSF)*T                           POTS2100
      IPOT(44) = IPOT(39)                                              POTS2110
      IPOT(47) = TSF/200.*T                                            POTS2120
      IPOT(59) = IPOT(47)                                              POTS2130
      IPOT(66) = 0.25*TSF/20.*T                                        POTS2140
      IPOT(67) = IPOT(66)                                              POTS2150
      IPOT(95) = 2.*AKT2/(10000.*AMUF)*T*PARAM(175)                    POTS2160
      IPOT(97) = IPOT(03)                                              POTS2170
      IPOT(04) = 0.0                                                   POTS2000
      IPOT(05) = 0.0                                                   POTS2010
      IPOT(06) = 0.0                                                   POTS2020
      IPOT(07) = 0.0                                                   POTS2030
 1024 CONTINUE                                                         POTS2180
      IF(IAX.EQ.2) GO TO 1021                                          POTS2190
C############################################                          POTS2200
C#### SOLID REAR AXLE LOGIC FOR 680      #####                          POTS2210
C############################################                          POTS2220
            CALL SSRP(10,IRLERR)                                       POTS2250
      IPOT(09 )=( 1./AMUR)*T*PARAM(175)   * SFSF
      IPOT(10 )=(AKT3/(5000.0*AMUR))*T*PARAM(175)                      POTS1180
      IPOT(11 )=(AKT4/(5000.0*AMUR))*T*PARAM(175)                      POTS1190
      IPOT(12 )=T*PARAM(175)/AMS * SFSF * 10.
      IPOT(13 )=IPOT(09 )
      IPOT(15 )=(10.0*TS/AIR)*T*PARAM(175)  * SFSF * 10.
      IPOT(17 )=0.40*T*PARAM(175)                                      POTS2280
      IPOT(26)=(ABS(RR)/(4000.*TS))*T*0.1                              POTS2290
      IPOT(28)=PARAM(175)*T                                            POTS1300
      IPOT(35 )=(HUN*TSO2*T)
      IPOT(36 )=(TSO2/40.0)*T                                          POTS2310
      IPOT(45 )=IPOT(36 )                                              POTS2320
      IPOT(46 )=IPOT(35)
      IPOT(53 )=IPOT(26 )                                              POTS2300
      IPOT(109)=(TRO2/40.0)*T                                          POTS2350
      IPOT(115)=IPOT(109)                                              POTS2360
      IPOT(71) =0.
```

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      IPOT(80 )=0.
      IPOT(81 )=0.
      IPOT(82 )=0.
      GO TO 1022                                                        POTS2460
 1021 CONTINUE                                                          POTS2470
C############################################                           POTS2480
C#### SPLIT REAR AXLE LOGIC FOR 680     #####                           POTS2490
C############################################                           POTS2500
             CALL SSRM(10,IRLERR)                                       POTS2530
      IPOT(10)=AKT3*2.0/(5000.0*AMUR)*T*PARAM(175)
      IPOT(12 )=T*PARAM(175)/AMS    * SFSF * 10.
      IPOT(17)=PARAM(175)*T
      IPOT(28)=PARAM(175)*T
      IPOT(13)=2.0/(      AMUR)*T*PARAM(175) * SFSF
      IPOT(71)=(RR/(100.*TR**2))*T
      IPOT(80 )=AKT4*2.0/(5000.0*AMUR)*T*PARAM(175)                     POTS2610
      IPOT(81 )=2.0/(      AMUR)*T*PARAM(175)    * SFSF
      IPOT(82 )=T*PARAM(175)/AMS    * SFSF * 10.
      IPOT(09) = 0.0                                                    POTS264C
      IPOT(11) = 0.0                                                    POTS2660
      IPOT(15 )=0.
      IPOT(26 )=0.
      IPOT(35 )=0.
      IPOT(36 )=0.
      IPOT(45 )=0.
      IPOT(46 )=0.
      IPOT(53 )=0.
      IPOT(109)=0.
      IPOT(115)=0.
 1022 CONTINUE                                                          POTS2800
C     DUAL TIRES ON SOLID REAR AXLE                                     POTS2810
C                   IDULTR = 0, NO DUALS                                POTS2820
C                          = 1, DUALS                                   POTS2830
      IF(IDULTR.NE.1) GO TO 1026                                        POTS2840
      IPOT(10) = 2.*IPOT(10)                                            POTS2850
      IPOT(11) = 2.*IPOT(11)                                            POTS2860
      IPOT(83) = 2.*IPOT(83)                                            POTS2870
      IPOT(113) = 2.*IPOT(113)                                          POTS2880
 1026 CONTINUE                                                          POTS2890
C        IDRSW=0, REAR WHEEL DRIVE                                      POTS2900
C             =1, FOUR WHEEL DRIVE                                      POTS2910
      IF(IDRSW.NE.1) GO TO 1025                                         POTS2920
      IPOT(51)=((RWSF*4.*AKT1)/(10000.*AIFBR))*T*0.1
      IPOT(52) = (4./AIFBR)*T*PARAM(238)
      IPOT(90) = (AIFBRP/AIFBR)*T
      IPOT(91) = IPOT(90)                                               POTS2960
      IPOT(102)=((RWSF*4.*AKT2)/(10000.*AIFBR))*T*0.1
      IPOT(103)= (4./AIFBR)*T*PARAM(239)
 1025 CONTINUE                                                          POTS2990
      RETURN                                                            POTS3000
      END                                                               POTS3010
```

2.1.7 MODEL

PRESENTED HERE IS THE FORTRAN LISTING FOR THE MATHEMATICAL MODEL SUBPROGRAM. THE FOLLOWING IS PERFORMED IN MODEL:

1) Reading of the analog-to-digital converter (ADC) variables.
2) Computation of simulation time.
3) Calculation of digital model equations.
4) Data preparation for output of the digital-to-analog converter (DAC) variables.
5) Detection, limiting, and flagging of ADC and DAC variable overloads.
6) Collection of TRACK data for output at the end of a run.

```
C     SUBROUTINE MODEL
      SUBROUTINE MODEL
C***********************************************************************
C     THIS SUBPROGRAM PERFORMS THE FOLLOWING :
C        1) READING OF THE ANALOG-TO-DIGITAL(ADC) CONVERTER VARIABLES
C        2) COMPUTION OF SIMULATION TIME
C        3) CALCULATION OF DIGITAL MODEL EQUATIONS
C        4) DATA PREPARATION FOR OUTPUT ON THE DIGITAL-TO-ANALOG(D/A)
C           CONVERTERS
C        5) DETECTION, LIMITING, AND FLAGGING OF ADC AND D/A VARIABLE
C           OVERLOADS
C     6) COLLECTION OF TRACK DATA FOR OUTPUT AT THE END OF RUN
C***********************************************************************
      COMMON/START/ ZDUMMY(4)
      COMMON/EMON/IERDAC(10),TERDAC(10),IDACK,IENDR(20)
      COMMON/ERMON2/ IERADC(10),TERADC(10),IADCK
      COMMON/DACADC/ NAMDAC,NAMADC,IDAC,IADC,ADCNUM,DACNUM
      COMMON/AERO/SFXS,SFYS,SFZS,SNTHES,SNPHIS,SNPSIS,APLUSB,IAERO
      COMMON/DULVAR/Z3ID,Z4ID,Z5OD,Z6OD,
     1              F3RID,F4RID,F5ROD,F6ROD,
     1              U3ID,U4ID,U5OD,U6OD,
     1              V3ID,V4ID,V5OD,V6OD,
     1              W3ID,W4ID,W5OD,W6OD,
     1              UG3ID,UG4ID,UG5OD,UG6OD,
     1              VG3ID,VG4ID,VG5OD,VG6OD,
     1              UG3IDP,UG4IDP,UG5ODP,UG6ODP,
     1              S3ID,S4ID,S5OD,S6OD,
     1              CF3ID,CF4ID,CF5OD,CF6OD,
     1              AMUI3,AMUI4,AMUI5,AMUI6,
     1              ALTQ3P,ALTQ4P,
     1              OTM3P,OTM4P,OTM5,OTM6
      COMMON/DUALS/IDULTR,NWHEEL,TIRO2,TORO2,TIRTOR,VBRZRP,
     1 FXU5,FXU6,FYU5,FYU6,ALTQ5,ALTQ6,FSI3,FSI4,FSI5,FSI6,PPHIR
      COMMON/PAUL/ D1,D2,D3,D4,SFYU,TMP,SNPHIU,SNTHEU,SNPSIU,
     1QDT,PDT, RDT ,UDT,VDT,WDT,PHIDT,THEDT,PSIDT,XDT,YDT,ZDT,
     1 AKK1,AKK2,                            THS1,THS2,
     1AMT1,AMT2,SN,SFXU,ETVDT,ETAX,ETAL,
     1 ZIP(4),PHII(4),
     1       U1I(4),BAMI(4),MUP(4),SAMI(4),FI(4),FXUI(4),FYUI(4),GI(4),
     1       ALFI(4),BETIP(4),BETIBR(4),SLIPI(4),AM1I(4),AM2I(4),UOI(4),
     1       FCI(4),FCIMAX(4),PSI(4),
     1       ABI(4),BETAI(4),AMUI(4),SNI(4),RMI(4),GBI(4),FRIBR(4),
     1       RWZI(4),ZI(4),FRI(4),      UI(4),VI(4),WI(4),UGI(4),
     1       VGI(4),SINPSI(4),PSII(4),COSPSI(4),UGIP(4),PHICGI(4),CVI(4)
     1,ALTQ(4),OTM(4),SALTQ,FOTM,ROTM
     1,AP1,AP2,AP3,AP4,AR1,AR2,AR3,AR4,ANTI1,ANTI2,ANTI3,ANTI4
     1,DLIS(4),ZIMX(4),FBS1,FBS2,FBS3,FBS4
     1,PHIDMX
      COMMON/APL/ OPEN  ,RTSW  ,LDTSW ,RBSW
      COMMON/SPLTAX/ SPSR3,SPSR4,IAX
      COMMON/SOLDAX/ PHIFNT(07),THEFNT(07),
     1     PSIFNT(7),PHIRR(7),THERR(7),PSIRR(7)
      COMMON/OUTVAR/ POUT,QOUT,ROUT,UOUT,VOUT,WOUT,XOUT,YOUT,ZOUT,
     1PDTOUT,QDTOUT,RDTOUT,THEOUT,PHIOUT,PSIOUT,UDTOUT,VDTOUT,WDTOUT
      COMMON/EXTRA/ PSI3S,PSI4S,BTV,AYSTI
      COMMON/THINGS/TMAX1,TMAX2,TMAX3,TQRMAX,TQFMAX,PSIMAX,ONER
      COMMON/CACATO/EPSK1,EPSK2,FEE1,FEE2,THE1,THE2
      COMMON/DELS/DELSWC
      COMMON/XYZ/NUMBR
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      COMMON/EFFS/ANUM,ADEN,ANUMDT,ADENDT,ANUMO,ADENO,ANUMDO,ADENDO,      MODE 490
     1   ANOUT,ADOUT                                                      MODE 500
      COMMON/XBS/XB(30),NS(4,30),DELX(4),XI(4),NNN                        MODE 510
      COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI,PO,QO,RO,UO,VO,WO,XO,     MODE 520
     1    YO,ZO,THEO,PHIO,PSIO                                            MODE 530
      COMMON/UVW/VC,UIN                                                   MODE 540
      COMMON/EES/O1,O2,O3,E4,E5,E6                                        MODE 550
      COMMON/ZILCH/TQMAXF,TQMAXR,AKTQF,AKTQR,TQDRF,TQDRR,IDRSW            MODE 560
      COMMON/INOUT/ IN(32),DACO(48),ISW1,ISW7,IPRT                        MODE 570
      COMMON/COMBLK/AIXP,SM,AIYP,AIXZP,GAM1,GAM2,GAM3,AIXBR,AIYBR,        MODE 580
     1    AIZBR,A1,A2,AIXZBR,A12,E1,E2,E3,DELTA,GV1,GV2,GP1,GP2,GR1,      MODE 590
     1    GR2,CIP,CIVP,RZF,RZR,A2T,CA20,CA23,               ANGNL,ANGNLO  MODE 600
     1    ,TRO2,TFO2,TSO2,G,THRD,TWN7,R2T,RA20,RA23,ONEOA,ONEOD           MODE 610
     1,TSFO2                                                              MODE 620
      COMMON/SWITCH/ ISW                                                  MODE 630
      COMMON/OPSW/IHSW                                                    MODE 640
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)                MODE 650
      COMMON/NEWER/TIME25,TIME10,PSI5,PHIMAX,DSWMAX                       MODE 660
      COMMON/NONAME/XEND,O,EXIT2                                          MODE 670
      COMMON/COMVAR/ AXAVE,CUVRAT,BETDMX,CURTBP,TIMDEC,JUMP,DELSTR,DEL,   MODE 680
     1               AXI,CURVAV,ABBTV,AYMAX,RMAX,DELBET,DELPSI,BETAMX,    MODE 690
     1               TIMBMP,GETDI,TIMIN5,       TSTEP ,    IVHTP          MODE 700
      COMMON/TIMBLK/JJTIME,TIME,DT                                        MODE 710
      COMMON/DEVICE/KEYBD,ITTY,ICDRD,LPTR,LPNT                            MODE 720
      COMMON/TRACK/JIN,IKEEP,ATRACK,ISAMP,ONTIM,OFFTIM,ITRA,              MODE 730
     1 ITRAA,ITRNA,ITRIA                                                  MODE 740
      COMMON/IO/DACPLA,ADCPLA,SCALDC,SCALAC                               MODE 750
      COMMON/SPRING/  DLSUS1,DLSUS2,DLSUS3,DLSUS4,DELSF1(10),DELSF2(10),
     1DELSR3(10),DELSR4(10),FDLSF1(10),FDLSF2(10),FDLSR3(10),FDLSR4(10),
     1NDELF1,NDELF2,NDELR3,NDELR4
      REAL*4 ZDUMMY                                                       MODE 780
      EQUIVALENCE (BVALUE(1),ZDUMMY(1))                                   MODE 790
      EQUIVALENCE  (APF(1),APF1),(APR(1),APR1),(MUS(1),MUSF),             MODE 800
     1             (APF(2),APF2),(APR(2),APR2),(MUS(2),MUSR)              MODE 810
      EQUIVALENCE                                                         MODE 820
     1   (PARAM( 1),AMS)     , (PARAM( 2),AMUF)   , (PARAM( 3),AMUR)    , MODE 830
     1   (PARAM( 4),ZF)      , (PARAM( 5),ZR)     , (PARAM( 6),A)       , MODE 840
     1   (PARAM( 7),B)       , (PARAM( 8),TF)     , (PARAM( 9),TR)      , MODE 850
     1   (PARAM(10),TS)      , (PARAM(11),AIX)    , (PARAM(12),AIY)     , MODE 860
     1   (PARAM(13),AIZ)     , (PARAM(14),AIXZ)   , (PARAM(15),AIR)     , MODE 870
     1   (PARAM(16),CF)      , (PARAM(17),RF)     ,                       MODE 880
     1   (PARAM(19),AKF1)    , (PARAM(20),AKF2)   , (PARAM(21),AKR3)    , MODE 890
     1   (PARAM(22),AKR4)    , (PARAM(23),CR)     , (PARAM(24),RR)      , MODE 910
     1   (PARAM(25),CF1P)    , (PARAM(26),CF2P)   , (PARAM(27),CR3P)    , MODE 900
     1   (PARAM(28),CR4P)                         , (PARAM(30),AKRS)    , MODE 920
     1   (PARAM(31),RW)                           , (PARAM(33),OT)      , MODE 930
     1   (PARAM(34),CA0)     , (PARAM(35),CA1)    , (PARAM(36),CA2)     , MODE 940
     1   (PARAM(37),CA3)     , (PARAM(38),CA4)    , (PARAM(39),TIR )    , MODE 950
     1   (PARAM(44),LAFT)    , (PARAM(41),AKSC)   , (PARAM(42),ANG)     , MODE 960
     1   (PARAM(43),LAFC)    , (PARAM(40),TOR )   , (PARAM(45),LARC)      MODE 970
      EQUIVALENCE                                                         MODE 980
     1   (PARAM(46),LART)    , (PARAM(47),AIFW)   , (PARAM(48),AIF)     , MODE 990
     1   (PARAM(49),AIWF)    , (PARAM(50),AIWR)   , (PARAM(51),AID)     , MODE1000
     1   (PARAM(52),ARBR)    , (PARAM(53),TSF )   , (PARAM(54),AKFS)    , MODE1010
     1   (PARAM(55),PTBR)    , (PARAM(56),YSA1)   , (PARAM(57),YSA2)    , MODE1020
     1   (PARAM(58),YHS1)    , (PARAM(59),YHS2)   , (PARAM(60),AKD)     , MODE1030
     1   (PARAM(61), AIDF)   , (PARAM(62),ARFBR)  , (PARAM(63),PIN)     , MODE1040
     1   (PARAM(64),QIN)     , (PARAM(65),RIN)    , (PARAM(66),UIZ)     , MODE1050
     1   (PARAM(67),VIN)     , (PARAM(68),WIN)    , (PARAM(69),XIN)     , MODE1060
     1   (PARAM(70),YIN)     , (PARAM(71),ZIN)    , (PARAM(72),THEIN)   , MODE1070
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1   (PARAM(73),PHIIN)   , (PARAM(74),PSIIN)  , (PARAM(75),DTIN)    ,  MODE1080
1   (PARAM(76),TEND)    , (PARAM(77),AKT1)   , (PARAM(78),AKT2)   ,   MODE1090
1   (PARAM(79),AKT3)    , (PARAM(80),AKT4)   , (PARAM(81),RPS1)   ,   MODE1100
1   (PARAM(82),RPS2)    , (PARAM(83),RPS3)   , (PARAM(84),RPS4)    ,  MODE1110
1   (PARAM(85),B1)      , (PARAM(86),B2)     , (PARAM(87),B3)         MODE1120
 EQUIVALENCE                                                          MODE1130
1 (PARAM(88),B4),          (PARAM( 89),DEL1DN),(PARAM( 90),DEL2DN),   MODE1140
1    (PARAM( 91),DEL3DN),(PARAM( 92),DELFIN), (PARAM( 93),DELRIN),    MODE1150
1    (PARAM( 94),DEL3IN), (PARAM( 95),PHIDN), (PARAM(96),PHIRN),      MODE1160
1    (PARAM( 97),DFW1IN), (PARAM( 98),DFW2IN),(PARAM( 99),U1PIN),     MODE1170
1    (PARAM(100),U2PIN),  (PARAM(101),U3PIN), (PARAM(102),U4PIN),     MODE1180
1    (PARAM(103),S1PIN),  (PARAM(104),S2PIN), (PARAM(105),S3PIN),     MODE1190
1    (PARAM(106),S4PIN), (PARAM(107),PPRT),(PARAM(108),FREQ)          MODE1200
1,(PARAM(110),TQMAX),(PARAM(111),AKTQ),(PARAM(112),VCIN)              MODE1210
1,(PARAM(113),SWMT),(PARAM(114),DSWCM),(PARAM(115),TST),              MODE1220
1(PARAM(116),DSLP),(PARAM(117),CGAM),(PARAM(118),CS)                  MODE1230
1  ,(PARAM(119),TQRBR),(PARAM(120),TQFBR)                             MODE1240
1  ,(PARAM(121),PFL),(PARAM(122),TTD),(PARAM(123),DSW)                MODE1250
1   ,(PARAM(124),TSW)                                                 MODE1260
 EQUIVALENCE                                                          MODE1270
1  (PARAM(130),AMCR),(PARAM(131),ESP),(PARAM(132),AKSL1),             MODE1280
1   (PARAM(133),AKSL2),(PARAM(134),AA1),(PARAM(135),AA2),             MODE1290
1   (PARAM(136),CCR),(PARAM(137),CFCR),(PARAM(138),AP),               MODE1300
1   (PARAM(139),EP1),(PARAM(140),EP2),                                MODE1310
1 (PARAM(169),SNT),(PARAM(170),SNS0),(PARAM(171),SNS1),               MODE1320
1    (PARAM(182),SII(1))                                              MODE1330
 EQUIVALENCE (PARAM(202),APF(1)),(PARAM(204),APR(1)),                 MODE1340
1    (PARAM(206),MUS(1))                                              MODE1350
 EQUIVALENCE                                                          MODE1360
1    (PARAM(223),CR1C),(PARAM(224),CR1T),(PARAM(225),CR2C),           MODE1370
1    (PARAM(226),CR2T),(PARAM(227),CR3C),(PARAM(228),CR3T),           MODE1380
1    (PARAM(229),CR4C),(PARAM(230),CR4T),(PARAM(231),AH1),            MODE1390
1    (PARAM(232),AH2),(PARAM(233),ALAMBD)     ,
1 (PARAM(242),AKCF),(PARAM(243),AKCR),(PARAM(244),AKSR)               MODE1420
 EQUIVALENCE (PARAM(245),RB(1)),(PARAM(249),TFK(1)),                  MODE1430
1              (PARAM(252),TRK(1)),                                   MODE1440
1              (PARAM(255),OFC0),(PARAM(256),OFC1),(PARAM(257),OFC2),MODE1450
1              (PARAM(258),OFC3),(PARAM(262),OBC3),                   MODE1460
1              (PARAM(259),ORC0),(PARAM(260),ORC1),(PARAM(261),ORC2)  MODE1470
 EQUIVALENCE (PARAM(263),CP0F),(PARAM(264),CP1F),                     MODE1480
1(PARAM(265),CP2F),(PARAM(266),CP0R),(PARAM(267),CP1R),               MODE1490
1(PARAM(268),CP2R),(PARAM(269),CR0F),(PARAM(270),CR1F),               MODE1500
1(PARAM(271),CR2F),(PARAM(272),CR0R),(PARAM(273),CR1R),               MODE1510
1(PARAM(274),CR2R)                                                    MODE1520
 EQUIVALENCE (RB(1),RB1),(RB(2),RB2)                                  MODE1530
 EQUIVALENCE (RB(3),RB3),(RB(4),RB4)                                  MODE1540
 EQUIVALENCE (TFK(1),AFK1),(TRK(1),ARK1)                              MODE1550
 EQUIVALENCE (TFK(2),AFK2),(TRK(2),ARK2)                              MODE1560
 EQUIVALENCE (TFK(3),AFK3),(TRK(3),ARK3)                              MODE1570
 EQUIVALENCE                                                          MODE1580
1    (PARAM(284),HFC),(PARAM(285),HRC),                               MODE1590
1    (PARAM(290),ROT),(PARAM(291),RA0),(PARAM(292),RA1),              MODE1600
1    (PARAM(293),RA2),(PARAM(294),RA3),(PARAM(295),RA4)               MODE1610
 EQUIVALENCE                                                          MODE1620
1(PARAM(296),DEL1DT),(PARAM(297),DEL2DT),(PARAM(298),DEL3DT),         MODE1630
1(PARAM(299),DEL1),(PARAM(300),DEL2),(PARAM(301),DEL3),               MODE1640
1(PARAM(302),PHIRD),(PARAM(303),PHIR),(PARAM(304),DELFW1),            MODE1650
1(PARAM(305),DELFW2),(PARAM(306),U1P),(PARAM(307),U2P),               MODE1660
1(PARAM(308),U3P),(PARAM(309),U4P),(PARAM(310),S1P),                  MODE1670
1(PARAM(311),S2P),(PARAM(312),S3P),(PARAM(313),S4P),                  MODE1680
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     1(PARAM(314),QUAN1),(PARAM(315),QUAN2),(PARAM(316),QUAN3),           MODE1690
     1(PARAM(317),QUAN4),(PARAM(318),ARPS3),(PARAM(319),ARPS4),           MODE1700
     1(PARAM(320),RWZ1A),(PARAM(321),RWZ2A),(PARAM(322),RWZ3A),
     1(PARAM(323),RWZ4A),(PARAM(324),IOUT(1))
      EQUIVALENCE (RWZI(1),RWZ1),(ZI(1),Z1),(FRI(1),FR1),(AKTI(1),AKT1),MODE1730
     1            (RWZI(2),RWZ2),(ZI(2),Z2),(FRI(2),FR2),(AKTI(2),AKT2),MODE1740
     1            (RWZI(3),RWZ3),(ZI(3),Z3),(FRI(3),FR3),(AKTI(3),AKT3),MODE1750
     1            (RWZI(4),RWZ4),(ZI(4),Z4),(FRI(4),FR4),(AKTI(4),AKT4),MODE1760
     1(UI(1),U1),(VI(1),V1),(WI(1),W1),(UGI(1),UG1),(VGI(1),VG1),         MODE1770
     1(UI(2),U2),(VI(2),V2),(WI(2),W2),(UGI(2),UG2),(VGI(2),VG2),         MODE1780
     1(UI(3),U3),(VI(3),V3),(WI(3),W3),(UGI(3),UG3),(VGI(3),VG3),         MODE1790
     1(UI(4),U4),(VI(4),V4),(WI(4),W4),(UGI(4),UG4),(VGI(4),VG4),         MODE1800
     1(SINPSI(1),SINPS1),(PSII(1),PSI1),(COSPSI(1),COSPS1),(UGIP(1),UG1PMODE1810
     1),(PHICGI(1),PHICG1),(CVI(1),CV1),(ABI(1),AB1),(BETAI(1),BETA1),   MODE1820
     1(SINPSI(2),SINPS2),(PSII(2),PSI2),(COSPSI(2),COSPS2),(UGIP(2),UG2PMODE1830
     1),(PHICGI(2),PHICG2),(CVI(2),CV2),(ABI(2),AB2),(BETAI(2),BETA2),   MODE1840
     1(SINPSI(3),SINPS3),(PSII(3),PSI3),(COSPSI(3),COSPS3),(UGIP(3),UG3PMODE1850
     1),(PHICGI(3),PHICG3),(CVI(3),CV3),(ABI(3),AB3),(BETAI(3),BETA3),   MODE1860
     1(SINPSI(4),SINPS4),(PSII(4),PSI4),(COSPSI(4),COSPS4),(UGIP(4),UG4PMODE1870
     1),(PHICGI(4),PHICG4),(CVI(4),CV4),(ABI(4),AB4),(BETAI(4),BETA4)    MODE1880
      EQUIVALENCE (AMUI(1),AMU1),(SNI(1),SN1),(RMI(1),RM1),(GBI(1),GB1),MODE1890
     1            (AMUI(2),AMU2),(SNI(2),SN2),(RMI(2),RM2),(GBI(2),GB2),MODE1900
     1            (AMUI(3),AMU3),(SNI(3),SN3),(RMI(3),RM3),(GBI(3),GB3),MODE1910
     1            (AMUI(4),AMU4),(SNI(4),SN4),(RMI(4),RM4),(GBI(4),GB4),MODE1920
     1(FRIBR(1),FR1BR),(ALFI(1),ALF1),(BETIP(1),BET1P),(BETIBR(1),BET1BRMODE1930
     1),(SLIPI(1),SLIP1),(AM1I(1),AM11),(AM2I(1),AM21),(U0I(1),U01),     MODE1940
     1(FRIBR(2),FR2BR),(ALFI(2),ALF2),(BETIP(2),BET2P),(BETIBR(2),BET2BRMODE1950
     1),(SLIPI(2),SLIP2),(AM1I(2),AM12),(AM2I(2),AM22),(U0I(2),U02),     MODE1960
     1(FRIBR(3),FR3BR),(ALFI(3),ALF3),(BETIP(3),BET3P),(BETIBR(3),BET3BRMODE1970
     1),(SLIPI(3),SLIP3),(AM1I(3),AM13),(AM2I(3),AM23),(U0I(3),U03),     MODE1980
     1(FRIBR(4),FR4BR),(ALFI(4),ALF4),(BETIP(4),BET4P),(BETIBR(4),BET4BRMODE1990
     1),(SLIPI(4),SLIP4),(AM1I(4),AM14),(AM2I(4),AM24),(U0I(4),U04),     MODE2000
     1(U1I(1),U11),(BAMI(1),BAM1),(SII(1),SI1),(SAMI(1),SAM1),(FI(1),F1) MODE2010
     1,                                                                   MODE2020
     1(U1I(2),U12),(BAMI(2),BAM2),(SII(2),SI2),(SAMI(2),SAM2),(FI(2),F2) MODE2030
     1,                                                                   MODE2040
     1(U1I(3),U13),(BAMI(3),BAM3),(SII(3),SI3),(SAMI(3),SAM3),(FI(3),F3) MODE2050
     1,                                                                   MODE2060
     1(U1I(4),U14),(BAMI(4),BAM4),(SII(4),SI4),(SAMI(4),SAM4),(FI(4),F4) MODE2070
      EQUIVALENCE (FXUI(1),FXU1),(FYUI(1),FYU1),(GI(1),G1),(FCI(1),FC1),MODE2080
     1            (FXUI(2),FXU2),(FYUI(2),FYU2),(GI(2),G2),(FCI(2),FC2),MODE2090
     1            (FXUI(3),FXU3),(FYUI(3),FYU3),(GI(3),G3),(FCI(3),FC3),MODE2100
     1            (FXUI(4),FXU4),(FYUI(4),FYU4),(GI(4),G4),(FCI(4),FC4),MODE2110
     1(FCIMAX(1),FC1MAX),(FSI(1),FS1),                                    MODE2120
     1(FCIMAX(2),FC2MAX),(FSI(2),FS2),                                    MODE2130
     1(FCIMAX(3),FC3MAX),(FSI(3),FS3),                                    MODE2140
     1(FCIMAX(4),FC4MAX),(FSI(4),FS4)                                     MODE2150
      EQUIVALENCE (ZIP(1),Z1P),(PHII(1),PHI1),                            MODE2160
     1            (ZIP(2),Z2P),(PHII(2),PHI2),                            MODE2170
     1            (ZIP(3),Z3P),(PHII(3),PHI3),                            MODE2180
     1            (ZIP(4),Z4P),(PHII(4),PHI4)                             MODE2190
      EQUIVALENCE (DL1S,DLIS(1)),(DL2S,DLIS(2)),(DL3S,DLIS(3))            MODE2200
     1     ,(DL4S,DLIS(4))                                                MODE2210
      EQUIVALENCE (PHIFD,DEL2DT) ,(PHIF,DEL2)                             MODE2220
      EQUIVALENCE  (PHIRD,DEL4DT),(PHIR,DEL4)                             MODE2230
      EQUIVALENCE (DLSUSI(1),DLSUS1),(DLSUSI(2),DLSUS2),                  MODE2240
     1            (DLSUSI(3),DLSUS3),(DLSUSI(4),DLSUS4)                   MODE2250
      DATA RAD/0.1745329E-1/                                              MODE2260
      DATA MPHIPS/17.6/                                                   MODE2270
      REAL*4 MPHIPS                                                       MODE2280
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      REAL*4 MUP    ,MUS(2),RB(4),TFK(3),TRK(3),SII(4),APF(2),APR(2)
      REAL*4 LAFC,LAFT,LARC,LART
      REAL*4 AKTI(4)
      REAL*4 ATRACK(2000)
      INTEGER*2 ITRAA(50),ITRNA(50),ITRIA(50),DACPLA(48),ADCPLA(48)
      INTEGER*2 NAMDAC(48),NAMADC(48),IDAC(48),IADC(48),ADCNUM,DACNUM
      REAL*4 IOUT(48),IN,      SCALAC(48),SCALDC(48)
      REAL*4 BVALUE(2)
      REAL*4 DLSUSI(4)
      INTEGER*2   RTSW  ,RBSW   ,LCTSW ,OPEN
C     ******************************************************************
C     USE A/D READ VALUES
C     CHECK FOR A/D OVER RANGE
C     ******************************************************************
      DO 10100 I=1,ADCNUM
      SADCO =   IN(I)
         IN(I) = AMAX1(-.9998,(AMIN1(.9998,  IN(I))))
      IF(SADCO.EQ.  IN(I)) GO TO 10105
      IADCK = IADCK+1
      IF(IADCK.GE.10) IADCK = 10
      IERADC(IADCK) = I
      TERADC(IADCK) = TIME
10105 CONTINUE
      BVALUE(ADCPLA(I))=IN(I)*SCALAC(I)
10100 CONTINUE
      IHSW=1
      TIME=FLOAT(JJTIME)*DT
      JJTIME=JJTIME+1
      ENTRY SPPG22
      ISW=1
      IF(TIME.GT.0.) GO TO 6
      DO 5 K=1,4
      FSI(K) = 0.
      ALTQ(K) = 0.
      ZIMX(K) = 100.
    5 CONTINUE
      PHIDMX = 0.
      CONVRT = 1./MPHIPS
C     AERODYNAMIC INITIALIZATION VARIABLES
      SFXS =0.
      SFYS =0.
      SFZS =0.
      SNTHES=0.
      SNPHIS =0.
      SNPSIS=0.
C     DUAL TIRE INITIALIZATION VARIABLES
      ALTQ5=0.0
      ALTQ6=0.0
      FSI3=0.0
      FSI4=0.0
      FSI5=0.0
      FSI6=0.0
      FXU5=0.0
      FXU6=0.0
      FYU5=0.0
      FYU6=0.0
      NBMP=PARAM(277)+0.5
    6 CONTINUE
C FUNCTION:  PSIFNT-COEFFICIENTS TO A POLYNOMIAL FIT OF FRONT WHEEL
C            TOE-IN AS A FUNCTION OF SUSPENSION DEFLECTION (DELI)
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C
C INPUTS:     PSIFNT-(DEGREES/INCH)
C             DELI-(INCHES)
C      *****************************************************************
C      INCREASING THE SPRUNG MASS OVER THAT FOR WHICH THE STATIC WHEEL
C      DEFLECTION IS MEASURED, YIELDS A DELFIN AND A DELRIN WHICH
C      IS A NEGATIVE NUMBER
C      *****************************************************************
C      DELFIN AND DELRIN REPRESENT A CHANGE IN STATIC DISPLACEMENT
C      OF THE FRONT AND REAR WHEELS DUE TO LOAD CONFIGURATIONS
C OUTPUTS:    POLY-(DEGREES)
C
C      DLIS (I=1,2,3,4) IS THE SUSPENSION DEFLECTION RELATIVE
C            TO THE UNLOADED POSITION FOR WHEEL I
      DL1S = DEL1 + DELFIN
      DL2S = DEL2 + DELFIN
      DL3S = DEL3 + DELRIN
      DL4S = DEL4 + DELRIN
      DLSUS1=DL1S
      DLSUS2=DL2S
      DLSUS3=DL3S
      DLSUS4=DL4S
C      IAX = 0   SOLID FRONT AND REAR SUSPENSIONS
C          = 1   INDEPENDENT FRONT AND SOLID REAR SUSPENSIONS
C          = 2  INDEPENDENT FRONT AND REAR SUSPENSIONS
      IF(IAX.EQ.0) DL1S = DL1S +  TFO2*PHIF
      IF(IAX.EQ.0) DL2S = DEL1 + DELFIN - TFO2*PHIF
      IF(IAX.LE.1) DL3S = DL3S   + TRO2*PHIR
      IF(IAX.LE.1) DL4S = DEL3 + DELRIN - TRO2*PHIR
C      SUSPENSION DEFLECTIONS FOR SPRING FORCES
      IF(IAX.EQ.0) DLSUS1 = DLSUS1 + TSF*PHIF/2.
      IF(IAX.EQ.0) DLSUS2 =  DEL1 + DELFIN - TSF*PHIF/2.
      IF(IAX.LE.1)DLSUS3=DLSUS3+TSO2*PHIR
      IF(IAX.LE.1) DLSUS4 = DEL3 + DELRIN -TSO2*PHIR
      PSI1=DELFW1+(POLY(DL1S,PSIFNT))*RAD+EPSK1
      PSI2=DELFW2-(POLY(DL2S,PSIFNT))*RAD+EPSK2
      PSI3S = AKRS*PHIR
      PSI4S = AKRS*PHIR
C
C FUNCTION:   PHIFNT-COEFFICIENTS TO A POLYNOMIAL FIT OF FRONT WHEEL
C             CAMBER AS A FUNCTION OF SUSPENSION DEFLECTION (DELI)
C
C INPUTS:     PHIFNT-(DEGREES/INCH)
C             DELI-(INCHES)
C
C OUTPUTS:    POLY-(DEGREES)
C
      PHI1=(POLY(DL1S,PHIFNT))*RAD+SIGN(1.,FS1)*FEE1
      PHI2=(-POLY(DL2S,PHIFNT))*RAD+SIGN(1.,FS2)*FEE2
      PHI3=PHIR
      PHI4=PHIR
C
C FUNCTION:   THEFNT-CASTER AS A FUNCTION OF SUSPENSION
C             DEFLECTION (DELI)
C
C INPUTS:     THEFNT (DEGREES/INCH)
C             DELI-(INCHES)
C
C OUTPUT:     POLY-(DEGREES)
C
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      THS1=(POLY(DL1S,THEFNT))*RAD+THE1                                MODE3490
      THS2=(POLY(DL2S,THEFNT))*RAD+THE2                                MODE3500
C                                                                      CMODE3510
C FUNCTION:  PSIRR-COEFFICIENTS TO A POLYNOMIAL FIT OF REAR WHEEL     CMODE3520
C            TOE-IN AS A FUNCTION OF SUSPENSION DEFLECTION (DELI)     CMODE3530
C                                                                      CMODE3540
C INPUTS:    PSIRR-(DEGREES/INCH)                                      CMODE3550
C            DELI-(INCHES)                                             CMODE3560
C                                                                      CMODE3570
C OUTPUTS:   POLY-(DEGREES)                                            CMODE3580
C                                                                      CMODE3590
C                                                                      CMODE3600
C FUNCTION:  PHIRR-COEFFICIENTS TO A POLYNOMIAL FIT OF REAR WHEEL     CMODE3610
C            CAMBER AS A FUNCTION OF SUSPENSION DEFLECTION (DELI)     CMODE3620
C                                                                      CMODE3630
C INPUTS:    PHIRR-(DEGREES/INCH)                                      CMODE3640
C            DELI-(INCHES)                                             CMODE3650
C                                                                      CMODE3660
C OUTPUTS:   POLY-(DEGREES)                                            CMODE3670
C                                                                      CMODE3680
      IF(IAX.LE.1)GO TO 7843                                           MODE3690
      PSI3S = POLY(DL3S,PSIRR)*RAD                                     MODE3700
      PSI4S = -POLY(DL4S,PSIRR)*RAD                                    MODE3710
      PHI3 =POLY(DL3S,PHIRR)*RAD                                       MODE3720
      PHI4=-POLY(DL4S,PHIRR)*RAD                                       MODE3730
 7843 CONTINUE                                                         MODE3740
      IF(IAX.NE.0.) GO TO 7844                                         MODE3750
      PSI1 = DELFW1-AKFS*PHIF+EPSK1                                    MODE3760
      PSI2 = DELFW2-AKFS*PHIF+EPSK2                                    MODE3770
      PHI1 = PHIF+FEE1                                                 MODE3780
      PHI2 = PHIF+FEE2                                                 MODE3790
 7844 CONTINUE                                                         MODE3800
      PHS1=YHS1+PHI1                                                   MODE3810
      PHS2=YHS2+PHI2                                                   MODE3820
C     CALCULATION OF FRONT BUMP STOP FORCES                            MODE3830
      FBS1 = XINT(DLSUS1,DELSF1,FDLSF1,NDELF1)
      FBS1 = FBS1 - AKF1*DLSUS1
      FBS2 = XINT(DLSUS2,DELSF2,FDLSF2,NDELF2)
      FBS2 = FBS2 - AKF2*DLSUS2
C     CALCULATION OF REAR BUMP STOP FORCES                             MODE3880
      FBS3 = XINT(DLSUS3,DELSR3,FDLSR3,NDELR3)
      FBS3 = FBS3 - AKR3*DLSUS3
      FBS4 = XINT(DLSUS4,DELSR4,FDLSR4,NDELR4)
      FBS4 = FBS4 - AKR4*DLSUS4
      NNN=PARAM(198)/(PARAM(75)*U    )+0.5                             MODE3930
  100 TM1=Z-A*THE                                                      MODE3940
      TM2=TFO2*PHI                                                     MODE3950
      Z1PP=TM1+TM2                                                     MODE3960
      Z1P=Z1PP+ZF                                                      MODE3970
      Z1=Z1P+DEL1 - DELX(1)
      IF(IAX.EQ.0.) Z1 = Z1 + TFO2*PHIF                                MODE3990
      Z2PP=TM1-TM2                                                     MODE4000
      Z2P=Z2PP+ZF                                                      MODE4010
      Z2=Z2P+DEL2 -DELX(2)
      IF(IAX.EQ.0.) Z2 = Z2 - TFO2*PHIF - DEL2 + DEL1                  MODE4030
C                                                                      MODE4040
C      FOR DUAL TIRES, TRO2 = (TORO2+TIRO2)/2.                         MODE4050
C                                                                      MODE4060
      TM1=Z+B*THE                                                      MODE4070
      TM2=TRO2*PHI                                                     MODE4080
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      Z3PP=TM1+TM2                                                      MODE4090
      Z3P=Z3PP+ZR                                                       MODE4100
      Z3=Z3P+DEL3 -DELX(3)
      IF(IAX.LE.1) Z3=Z3+TRO2*PHIR+DEL3-DEL3                            MODE4120
      Z4PP=TM1-TM2                                                      MODE4130
      Z4P=Z4PP+ZR                                                       MODE4140
      Z4=Z4P+DEL4 -DELX(4)
      IF(IAX.LE.1) Z4=Z4-TRO2*PHIR+DEL3-DEL4                            MODE4160
      DO 20 K=1,4                                                       MODE4170
      IF(PARAM(180).EQ.4.)RWZI(K) = PARAM(K+319)
      IF(PARAM(180).LT.4.)RWZI(K) = RW + ZI(K)
      IF(RWZI(K).LT.ZIMX(K)) ZIMX(K) = RWZI(K)                          MODE4190
      FRI(K) = 0.                                                       MODE4200
      IF(RWZI(K).GT.0.) FRI(K) = AKTI(K) * RWZI(K)                      MODE4210
   20 CONTINUE                                                          MODE4220
      TM1=U+ZF*Q                                                        MODE4230
      TM2=TFO2*R                                                        MODE4240
      U1=TM1-TM2                                                        MODE4250
      U2=TM1+TM2                                                        MODE4260
      TM1=U+ZR*Q                                                        MODE4270
      TM2=TRO2*R                                                        MODE4280
      U3=TM1-TM2                                                        MODE4290
      U4=TM1+TM2                                                        MODE4300
      VARZFP=V+A*R-ZF*P                                                 MODE4310
      VBRZRP=V-B*R-ZR*P                                                 MODE4320
      PPHIR=P                                                           MODE4330
      IF(IAX.LE.1) PPHIR=P+PHIRD                                        MODE4340
      PPHIF = P                                                         MODE4350
      IF(IAX.EQ.0) PPHIF = P + PHIFD                                    MODE4360
      V1 = VARZFP + Z1*PPHIF                                            MODE4370
      V2 = VARZFP + Z2*PPHIF                                            MODE4380
      V3=VBRZRP+Z3*PPHIR                                                MODE4390
      V4=VBRZRP+Z4*PPHIR                                                MODE4400
      WAQ=W-A*Q                                                         MODE4410
      WBQ = W + B*Q                                                     MODE4420
      TF2P = TFO2*PPHIF                                                 MODE4430
      TR2P = TRO2*PPHIR                                                 MODE4440
      W1=WAQ+TF2P+DEL1DT                                                MODE4450
      W2=WAQ-TF2P+DEL2DT                                                MODE4460
      IF(IAX.EQ.0) W2 = W2 + DEL1DT - DEL2DT                            MODE4470
      W3 = WBQ + TR2P + DEL3DT                                          MODE4480
      W4 = WBQ - TR2P + DEL3DT                                          MODE4490
      IF(IAX.EQ.2) W4 = W4 + DEL4DT - DEL3DT                            MODE4500
      IF(IDULTR.EQ.1) ALTQ(3) = ALTQ(3)/2.                              MODE4510
      IF(IDULTR.EQ.1) ALTQ(4) = ALTQ(4)/2.                              MODE4520
      PSI3 = PSI3S+ ALTQ(3)*AKSR                                        MODE4530
      PSI4 = PSI4S+ ALTQ(4)*AKSR                                        MODE4540
      DO 30 K=1,4                                                       MODE4550
      UGI(K) = UI(K) + THE*WI(K)                                        MODE4560
      VGI(K) = VI(K) - PHI*WI(K)                                        MODE4570
      SINPSI(K) = SIN(PSII(K))                                          MODE4580
      COSPSI(K) = COS(PSII(K))                                          MODE4590
      UGIP(K) = UGI(K) * COSPSI(K) + VGI(K) * SINPSI(K)                 MODE4600
   30 CONTINUE                                                          MODE4610
      CZ=COS(PSI)                                                       MODE4620
      SN=SIN(PSI)                                                       MODE4630
      DO 40 K=1,4                                                       MODE4640
      CVI(K) = SQRT(UI(K)*UI(K) + VI(K)*VI(K))*CONVRT                   MODE4650
      ABI(K) = ABS(UGI(K))                                              MODE4660
      BETAI(K) = ATAN(VGI(K)/ABI(K)) - PSII(K)*UGI(K)/ABI(K)            MODE4670
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```
      SNI(K) = SNS0 / SNT
   40 CONTINUE
C     INTFUN IS USED FOR ROAD PATCH WITH VARYING COEFFICIENT OF FRICTION
      INTFUN=PARAM(172)+0.5
      IF(INTFUN.EQ.0) GO TO 3497
      IF(INTFUN.NE.1) GO TO 3498
      X1=A*CZ-TFO2*SN  +X
      X2=A*CZ+TFO2*SN  +X
      X3=-B*CZ-TRO2*SN +X
      X4=-B*CZ+TRO2*SN+X
      TEMP=PARAM(173)+PARAM(174)
      TEMP=TEMP*12.0
      PPPP=PARAM(173)*12.0
      IF(X1.GT.PPPP      .AND.X1.LE.TEMP) SN1=SNS1/SNT
      IF(X2.GT.PPPP      .AND.X2.LE.TEMP) SN2=SNS1/SNT
      IF(X3.GT.PPPP      .AND.X3.LE.TEMP) SN3=SNS1/SNT
      IF(X4.GT.PPPP      .AND.X4.LE.TEMP) SN4=SNS1/SNT
      GO TO 3498
 3497 CONTINUE
      YY1=A*SN+TFO2*CZ  +Y
      Y2=A*SN-TFO2*CZ   +Y
      Y3=-B*SN+TRO2*CZ +Y
      Y4=-B*SN-TRO2*CZ+Y
      IF(YY1.LT.0.0)SN1=SNS1/SNT
      IF(Y2.LT.0.0) SN2=SNS1/SNT
      IF(Y3.LT.0.0) SN3=SNS1/SNT
      IF(Y4.LT.0.0)SN4=SNS1/SNT
 3498 CONTINUE
C     PARAM(314 -317) ARE EQUIVALENCED TO QUAN1 - 4
      DO 11 K=1,4
      SLIPI(K) = PARAM(K + 313)
      IF(SLIPI(K).LT.(-1.).OR.SLIPI(K).GT.1.) SLIPI(K)=SIGN(1.,SLIPI(K))
   11 CONTINUE
C     CALCULATION OF SIDE FORCE FRICTION COEFF
C
      CALL LFRIC
C
C     CIRCUMFERENTIAL FRICTION COEFF CALCULATION
C
      CALL CFRIC
C
C      ALIGNING TORQUE CALCULATIONS
C     OVER-TURNING MOMENT CALCULATIONS
C
      DO 4280 K=1,2
      ALTQ(K)=AFK1*FRI(K)*FSI(K)+SIGN(1.   ,FSI(K))*FSI(K)*FSI(K)  *AFK2
     1  +SIGN(1.   ,PHICGI(K))*FRI(K)*SQRT(ABS(PHICGI(K))) *AFK3
      OTM(K)=FRI(K)*(OFC1*FSI(K)+OFC2*FSI(K)*ABS(PHICGI(K))
     1       +OFC3*PHICGI(K))
      IF(IDULTR.EQ.1) GO TO 4280
      KK= K+2
      ALTQ(KK)=ARK1*FRI(KK)*FSI(KK)+SIGN(1.   ,FSI(KK))*FSI(KK)*FSI(KK)
     1*ARK2
     1  +SIGN(1.   ,PHICGI(KK))*FRI(KK)*SQRT(ABS(PHICGI(KK))) *ARK3
      OTM(KK)=FRI(KK)*(ORC1*FSI(KK)+ORC2*FSI(KK)*ABS(PHICGI(KK))+ORC3
     1  *PHICGI(KK))
 4280 CONTINUE
C     DUAL TIRES ON SOLID REAR AXLE
C                 IDULTR = 0, NO DUALS
C                        = 1, DUALS
```

```
C
      IF(IDULTR.EQ.1) CALL DUAL
C
      SALTQ=ALTQ(1)+ALTQ(2)+ALTQ(3)+ALTQ(4)
      FOTM=OTM(1)+OTM(2)
      ROTM=OTM(3)+CTM(4)
C  AERODYNAMIC FORCES AND MOMENTS - SFXS,SFYS,SFZS,SNPHIS,SNTHES,SNPSIS
C
      IF(IAERO.EQ.1) CALL AERODY
C
      SFXU=FXU1+FXU2+FXU3+FXU4+FXU5+FXU6+SFXS
      SFYU=FYU1+FYU2+FYU3+FYU4+FYU5+FYU6+SFYS
C     YAW AND PITCH MOMENT CALCULATIONS FOR INDEPENDENT FRONT AND
C      REAR SUSPENSIONS
      SNPSIU=A*(FYU1+FYU2)-B*(FYU3+FYU4)+TFO2*(FXU2-FXU1)
     1    +TRO2*(FXU4-FXU3) + SALTQ + SNPSIS
      SNTHEU=A*(S1P+S2P)-B*(S3P+S4P)-FXU1*Z1PP-FXU2*Z2PP
     1        -FXU3*Z3PP-FXU4*Z4PP   + SNTHES
      IF(IDULTR.NE.1) GO TO 4282
      SNPSIU = A*(FYU1+FYU2)-B*(FYU3+FYU4+FYU5+FYU6)+(FXU2-FXU1)*TFO2
     1  +(FXU4-FXU3)*TIRO2+(FXU6-FXU5)*TORO2+SALTQ+SNPSIS
4282  CONTINUE
C     IAX = 0   SOLID FRONT AND REAR SUSPENSIONS
C         = 1   INDEPENDENT FRONT AND SOLID REAR SUSPENSIONS
C         = 2  INDEPENDENT FRONT AND REAR SUSPENSIONS
      GO TO (4287,4288),IAX
C     ROLL MOMENT CALCULATION FOR SOLID FRONT AND REAR SUSPENSIONS
C      NO DUALS
      SNPHIU=TSFO2*(S2P-S1P)+TSO2*(S4P-S3P)-(FYU1+FYU2)*(ZF+DEL1)
     1         -(FYU3+FYU4+FYU5+FYU6)*(ZR+DEL3)+SNPHIS
      IF(IDULTR.NE.1) GO TO 4281
C     PITCH MOMENT CALCULATION FOR SOLID FRONT AND REAR SUSPENSIONS
C      REAR DUAL TIRES
      SNTHEU=A*(S1P+S2P)-B*(S3P+S4P)-FXU1*Z1PP-FXU2*Z2PP
     1          +FXU3*(ZR+DEL3+TIRO2*PHIR-Z3ID)
     1+FXU4*(ZR+DEL3-TIRO2*PHIR-Z4ID)+FXU5*(ZR+DEL3+TORO2*PHIR-Z5OD)
     1         +FXU6*(ZR+DEL3-TORO2*PHIR-Z6OD)   +SNTHES
 4281 CONTINUE
      GO TO 4289
 4287 IF(IDULTR.NE.1) GO TO 4290
C      YAW,ROLL AND PITCH MOMENT CALCULATIONS FOR INDEPENDENT FRONT AND
C      SOLID REAR SUSPENSIONS
C      REAR DUAL TIRES
      SNPHIU = TFO2*(S2P-S1P) +TSO2*(S4P-S3P) + FYU1*(Z1PP+HFC)
     1         + FYU2*(Z2PP+HFC) -(FYU3+FYU4+FYU5+FYU6)*(ZR+DEL3)
     1         + FOTM+SNPHIS
      SNTHEU=A*(S1P+S2P)-B*(S3P+S4P)-FXU1*Z1PP-FXU2*Z2PP
     1          +FXU3*(ZR+DEL3+TIRO2*PHIR-Z3ID)
     1+FXU4*(ZR+DEL3-TIRO2*PHIR-Z4ID)+FXU5*(ZR+DEL3+TORO2*PHIR-Z5OD)
     1         +FXU6*(ZR+DEL3-TORO2*PHIR-Z6OD)   +SNTHES
      GO TO 4289
C     ROLL MOMENT CALCULATION FOR INDEPENDENT FRONT AND SOLID
C      REAR SUSPENSIONS
C      NO DUALS
 4290 SNPHIU=TFO2*(S2P-S1P)+TSO2*(S4P-S3P)+FYU1*(Z1PP+HFC)
     1         +FYU2*(Z2PP+HFC)
     1                              -(FYU3+FYU4)*(DEL3+HRC+ZR)
     1 + FOTM + SNPHIS
      GO TO 4289
C     ROLL MOMENT CALCULATION FOR INDEPENDENT FRONT AND REAR SUSPENSIONS
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 4288 SNPHIU=TFO2*(S2P-S1P)+TRO2*(S4P-S3P)+FYU1*(Z1PP+HFC)
     1        +FYU2*(Z2PP+HFC)+FYU3*(Z3PP+HRC)+FYU4*(Z4PP+HRC)
     1 + FOTM+ROTM  + SNPHIS
 4289 CONTINUE
C     KINEMATIC CALCULATIONS
      IF(ISW.EQ.3) GO TO 7005
      QDT=(SFXU/SM-SNTHEU/GAM2)*ONEOA
      UDT=V*R-W*Q-G*THE-(A2*SFXU/SM-A1*SNTHEU/GAM2)*ONEOA
      WDT=U*Q-V*P-(S1P+S2P+S3P+S4P- SFZ3)/AMS
      TMP=W*P-U*R+G*PHI
      D1=SM*TMP+SFYU
      D2=-GAM3*TMP+SNPHIU
        D3=GAM1*TMP+SNPSIU
         VDT=(D1*E1+D2*GV1+D3*GV2)*ONEOD
      PDT=(-D1*E2+D2*GP1+D3*GP2)*ONEOD
      RDT=(D1*E3+D2*GR1+D3*GR2)*ONEOD
      PHIDT=P+R*THE
      THEDT=Q-R*PHI
  101 PSIDT=R + Q*PHI
      XDT=U*CZ-V*SN
      YDT=U*SN+V*CZ
      ZDT=W-U*THE+V*PHI
      ANUMDT = SQRT(U**2 + V**2)
      ADENDT=(FC1MAX+FC2MAX+FC3MAX+FC4MAX)
      ISWPQ=PARAM(127)+0.5
      ISWPQ=ISWPQ+1
      GO TO (7001,7002,7003,7004),ISWPQ
      GO TO 7001
 7002 PDT=0.0
      GO TO 7001
 7003 QDT=0.0
      GO TO 7001
 7004 PDT=0.0
      QDT=0.0
 7001 CONTINUE
 7005 CONTINUE
C
C ***********************************************************************
C
C     INTEGRATION OF DERIVATIVES DONE NEXT
      CALL NIEGRT(&100)
C
C     CALCULATION OF STEER AND BRAKE COMMANDS DONE NEXT
      CALL STRBRK
C
C ***********************************************************************
C
      IF(NBMP.EQ.0) GO TO 8499
      XI(1)=X    +A*CZ-TFO2*SN
      XI(2)=X    +A*CZ+TFO2*SN
      XI(3)=X    -B*CZ-TRO2*SN
      XI(4)=X    -B*CZ+TRO2*SN
      NUMBR = NUMBR + 1
      DO 8498 I=1,4
      DELX(I)=GETDEL(XI,I,PARAM(200),NBMP)
      GETDL = GETDL + DELX(I)
 8498 CONTINUE
 8499 CONTINUE
      PTB1=PTBR
      PTB2=PTBR
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      AKK1=1.0                                                          MODE6480
      AKK2=1.0                                                          MODE6490
      IF(PARAM(60).EQ.1.0)GO TO 4334                                    MODE6500
      CALL PTBAK(BETA1,FR1,AKK1,PTB1)                                   MODE6510
      CALL PTBAK(BETA2,FR2,AKK2,PTB2)                                   MODE6520
 4334 CONTINUE                                                          MODE6530
      IF(SWMT.LE.0.) GO TO 4333
      AMT1=FXU1*(PTB1*SINPS1-YSA1*COSPS1-Z1*(PHI1*COSPS1-PHS1))         MODE6540
     1   +FYU1*(-PTB1*AKK1*COSPS1-YSA1*SINPS1-Z1*(PHI1*SINPS1-THS1))    MODE6550
     1    -FR1*(-PTB1*(PHS1*COSPS1+THS1*SINPS1)+YSA1*(THS1*COSPS1-      MODE6560
     1      PHS1*SINPS1)-Z1*(PHS1*PHI1*SINPS1-THS1*PHI1*COSPS1))        MODE6570
      AMT2=FXU2*(PTB2*SINPS2-YSA2*COSPS2-Z2*(PHI2*COSPS2-PHS2))         MODE6580
     1   +FYU2*(-PTB2*AKK2*COSPS2-YSA2*SINPS2-Z2*(PHI2*SINPS2-THS2))    MODE6590
     1    -FR2*(-PTB2*(PHS2*COSPS2+THS2*SINPS2)+YSA2*(THS2*COSPS2-      MODE6600
     1      PHS2*SINPS2)-Z2*(PHS2*PHI2*SINPS2-THS2*PHI2*COSPS2))        MODE6610
 4333 CONTINUE
      AMT1 = SWMT*AMT1                                                  MODE6620
      AMT2 = SWMT*AMT2                                                  MODE6630
C     CALCULATION OF ANTI PITCH AND ROLL FORCES                         MODE6640
C     FOR SOLID AXLE DEL3 IS REAR AXLE VERTICAL ROLL CENTER             MODE6650
C     DL3S AND DL4S ARE REAR WHEEL SUSPENSION DEFLECTIONS               MODE6660
      AP1 = (CP0F + CP1F*DL1S + CP2F*DL1S*DL1S) * FXUI(1)               MODE6670
      AP2 = (CP0F + CP1F*DL2S + CP2F*DL2S*DL2S) * FXUI(2)               MODE6680
      AP3 = (CP0R + CP1R*DL3S + CP2R*DL3S*DL3S) * (FXUI(3)+FXU5)        MODE6690
      AP4 = (CP0R + CP1R*DL4S + CP2R*DL4S*DL4S) * (FXUI(4)+FXU6)        MODE6700
      AR1 = -(CR0F + CR1F*DL1S + CR2F*DL1S*DL1S) * FYUI(1)              MODE6710
      AR2 =  (CR0F + CR1F*DL2S + CR2F*DL2S*DL2S) * FYUI(2)              MODE6720
      AR3 = -(CR0R + CR1R*DL3S + CR2R*DL3S*DL3S) *(FYUI(3)+FYU5)        MODE6730
      AR4 =  (CR0R + CR1R*DL4S + CR2R*DL4S*DL4S) *(FYUI(4)+FYU6)        MODE6740
      ANTI1 = AP1 + AR1 - FBS1                                          MODE6750
      ANTI2 = AP2 + AR2 - FBS2                                          MODE6760
      ANTI3 = AP3 + AR3 - FBS3                                          MODE6770
      ANTI4 = AP4 + AR4 - FBS4                                          MODE6780
C                                                                       MODE6790
C ***********************************************************************MODE6800
C                                                                       MODE6810
C     SAMPLE VALUES TO CALCULATE THE COMPARISON VARIABLES               MODE6820
      CALL CVCALC                                                       MODE6830
C                                                                       MODE6840
C ***********************************************************************MODE6850
C     PREPARATION OF VARIABLES TO BE OUTPUT ON D/A CONVERTERS           MODE6860
      TEMP = (AMT1 + ALTQ(1)) / AIFW - RDTOUT                           MODE6870
      IOUT(01)=- TEMP          *PARAM(175)                              MODE6880
      TEMP=RZF+ZOUT-A*THEOUT+TFO2*PHIOUT                                MODE6890
      TEMP=TEMP-DELX(1)                                                 MODE6900
      IOUT(02)=TEMP                                                     MODE6910
      TEMP = (AMT2 + ALTQ(2))/ AIFW - RDTOUT                            MODE6920
      IOUT(03)=- TEMP          *PARAM(175)                              MODE6930
      TEMP=RZF+ZOUT-A*THEOUT-TFO2*PHIOUT                                MODE6940
      TEMP=TEMP-DELX(2)                                                 MODE6950
      IOUT(04)=TEMP                                                     MODE6960
      IOUT(09)=-TQFBR                                                   MODE7040
      IOUT(10)=-TQRBR                                                   MODE7050
      IOUT(11)=DELSWC                                                   MODE7060
      TEMP=(RZR+ZOUT+B*THEOUT+PHIOUT*TRO2)                              MODE7230
      TEMP=TEMP-DELX(3)                                                 MODE7240
      IOUT(18)=TEMP                                                     MODE7250
      TEMP=(RZR+ZOUT+B*THEOUT-PHIOUT*TRO2)                              MODE7260
      TEMP=TEMP-DELX(4)                                                 MODE7270
      IOUT(20)=TEMP                                                     MODE7280
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C###############################################
C### SPLIT FRONT AXLE ####
C###############################################
      TM1=TFO2*PDTOUT                                                   MODE6970
      TM2=A*QDTOUT                                                      MODE6980
      TM3=CIP                                                           MODE6990
      TEMP=-TM1+TM2+TM3-FYU1*SPSR3-SFZS/AMS                             MODE7000
      IOUT(06)=TEMP          *PARAM(175)                                MODE7010
      TEMP= TM1+TM2+TM3+FYU2*SPSR3 -SFZS/AMS                            MODE7020
      IOUT(08)=TEMP          *PARAM(175)                                MODE7030
      IOUT(05) = 0                                                      MODE7290
      IOUT(07) = 0                                                      MODE7300
C###############################################
C### SOLID REAR AXLE ####
C###############################################
      TEMP=(+TRO2+Z3*PHIR)*(AKT3/AIR)                                   MODE7070
      IOUT(13)=TEMP          *PARAM(175)                                MODE7080
      IF(IDULTR.EQ.1) IOUT(13) = 2.*IOUT(13)                            MODE7090
      TEMP=CIVP-B*QDTOUT-SFZS/AMS                                       MODE7100
      IOUT(14)=      TEMP          *PARAM(175)                          MODE7110
      TEMP = (-TRO2 + Z4*PHIR)*(AKT4/AIR)                               MODE7120
      IOUT(15)=TEMP          *PARAM(175)                                MODE7130
      IF(IDULTR.EQ.1) IOUT(15) = 2.*IOUT(15)                            MODE7140
      IF(IDULTR.NE.1) GO TO 7717                                        MODE7150
      TEMP=-PDTOUT-(FYU3*(-Z3ID+TIRO2*PHIR)+FYU4*(-Z4ID-TIRO2*PHIR))/AIRMODE7160
      TEMP=TEMP-(FYU5*(-Z5OD+TORO2*PHIR)+FYU6*(-Z6OD-TORO2*PHIR)-ROTM)  MODE7170
     1   /AIR                                                           MODE7180
      GO TO 7718                                                        MODE7190
 7717 TEMP=-PDTOUT-(FYU3*(TRO2*PHIR-Z3)+FYU4*(-TRO2*PHIR-Z4))/AIR       MODE7200
      TEMP = TEMP - ((FYU3+FYU4)*HRC - ROTM)/AIR                        MODE7210
 7718 IOUT(16)=TEMP*PARAM(175)                                          MODE7220
      IF(IAX.LE.1) GO TO 7719                                           MODE7330
C###############################################
C### SPLIT REAR AXLE ####
C###############################################
      TEMP   =G*(1.+A*AMS/(AMUR*(A+B)))-B*QDTOUT-TRO2*PDTOUT            MODE7340
     1        -FYU3*SPSR4 -SFZS/AMS                                     MODE7350
      IOUT(14)=TEMP          *PARAM(175)
      TEMP   =G*(1.+A*AMS/(AMUR*(A+B)))-B*QDTOUT+TRO2*PDTOUT            MODE7370
     1        +FYU4*SPSR4-SFZS/AMS                                      MODE7380
      IOUT(16)=TEMP          *PARAM(175)
      IOUT(13)=0                                                        MODE7400
      IOUT(15) = 0                                                      MODE7420
      GO TO 7720                                                        MODE7440
 7719 IF(IAX.EQ.1) GO TO 7720                                           MODE7450
C###############################################
C### SOLID FRONT AXLE ####
C###############################################
      IOUT(05) = (AKT1/AIF)*(TFO2+Z1*PHIF)        *PARAM(175)           MODE7460
      IOUT(06) = (A*QDTOUT + CIP -SFZS/AMS)*PARAM(175)                  MODE7470
      IOUT(07) = (AKT2/AIF)*(-TFO2+Z2*PHIF)       *PARAM(175)           MODE7480
      IOUT(08) = (-PDTOUT + (-FYU1*(-Z1+TFO2*PHIF)- FYU2*(-Z2-TFO2*PHIF)MODE7490
     1           + FOTM)/AIF)       *PARAM(175)                         MODE7500
 7720 CONTINUE                                                          MODE7510
      DO 3147 I=1,48                                                    MODE7520
      DACO(I)=BVALUE(DACPLA(I))/SCALDC(I)                               MODE7530
      SDACO=DACO(I)                                                     MODE7540
      DACO(I)=AMAX1(-.9995,(AMIN1(.9995,DACO(I))))                      MODE7550
      IF(SDACO.EQ.DACO(I)) GO TO 8317                                   MODE7560
      IDACK=IDACK+1                                                     MODE7570
```

```
      IF(IDACK.GT.10) IDACK=10
      IERDAC(IDACK) = I
      TERDAC(IDACK)=TIME
 8317 CONTINUE
 3147 CONTINUE
C     DATA COLLECTION FOR TRACK OPTION
      IF(TIME.LT.(ONTIM-.00001)) GO TO 8185
      IF(TIME.GT.OFFTIM) GO TO 8185
      IKEEP=IKEEP+1
      IF(IKEEP.NE.ISAMP) GO TO 8185
      IKEEP=0
      DO 8199 I=1,ITRA
      J=ITRAA(I)
      JIN=JIN+1
      IF(JIN.GT.1999) JIN=1999
      ATRACK(JIN)=BVALUE(J)
 8199 CONTINUE
 8185 CONTINUE
      RETURN
      END
```

2.1.8 LFRIC

PRESENTED HERE IS THE FORTRAN LISTING FOR THE LFRIC SUBPROGRAM. THE FOLLOWING CALCULATIONS ARE PERFORMED IN LFRIC:

1) Lateral coefficient of friction.
2) Circumferential tire force.
3) Lateral tire force.
4) Circumferential and lateral components of the tire force on the wheel.

```
C     SUBROUTINE LFRIC
      SUBROUTINE LFRIC
C*********************************************************************
C     THIS SUBPROGRAM PERFORMS THE FOLLOWING CALCULATIONS:
C        1) LATERAL COEFFICIENT OF FRICTION
C        2) CIRCUMFERENTIAL TIRE FORCE
C        3) LATERAL TIRE FORCE
C        4) CIRCUMFERENTIAL AND LATERAL COMPONENTS OF THE TIRE
C           FORCE ON THE WHEEL
C*********************************************************************
C FUNCTION:  AMUI-MAXIMUM LATERAL FRICTION COEFFICIENT
C
C INPUTS:    B1-(PARAM(85)),LOAD TERM COEFFICIENT OF LATERAL FRICTION
C            COEFFICIENT (1/LB)
C            B2-(PARAM(86)),VELOCITY TERM COEFFICIENT OF LATERAL
C            FRICTION COEFFICIENT (1/MPH)
C            B3-(PARAM(87)),CONSTANT TERM (UNITY)
C            B4-(PARAM(88)),QUADRATIC LOAD TERM(1/LB**2)
C            FRI-RADIAL TIRE FORCE (POUNDS)
C            CVI-VELOCITY OF VEHICLE (MPH)
C
C OUTPUT:    AMUI-MAXIMUM LATERAL FRICTION COEFFICIENT (UNITY)
C
      COMMON/PAUL/ D1,D2,D3,D4,SFYU,TMP,SNPHIU,SNTHEU,SNPSIU,
     1QDT,PDT, RDT ,UDT,VDT,WDT,PHIDT,THEDT,PSIDT,XDT,YDT,ZDT,
     1 AKK1,AKK2,                             THS1,THS2,
     1AMT1,AMT2,SN,SFXU,ETVDT,ETAX,ETAL,
     1 ZIP(4),PHII(4),
     1        U1I(4),BAMI(4),MUP(4),SAMI(4),FI(4),FXUI(4),FYUI(4),GI(4),
     1        ALFI(4),BETIP(4),BETIBR(4),SLIPI(4),AM1I(4),AM2I(4),UOI(4),
     1        FCI(4),FCIMAX(4),FSI(4),
     1        ABI(4),BETAI(4),AMUI(4),SNI(4),RMI(4),GBI(4),FRIBR(4),
     1        RWZI(4),ZI(4),FRI(4),         UI(4),VI(4),WI(4),UGI(4),
     1        VGI(4),SINPSI(4),PSII(4),COSPSI(4),UGIP(4),PHICGI(4),CVI(4)
     1,ALTQ(4),OTM(4),SALTQ,FOTM,ROTM
     1,AP1,AP2,AP3,AP4,AR1,AR2,AR3,AR4,ANTI1,ANTI2,ANTI3,ANTI4
     1,DLIS(4),ZIMX(4),FBS1,FBS2,FBS3,FBS4
     1,PHIDMX
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      COMMON/COMBLK/AIXP,SM,AIYP,AIXZP,GAM1,GAM2,GAM3,AIXBR,AIYBR,
     1    AIZBR,A1,A2,AIXZBR,A12,E1,E2,E3,DELTA,GV1,GV2,GP1,GP2,GR1,
     1    GR2,CIP,CIVP,RZF,RZR,A2T,CA20,CA23,               ANGNL,ANGNLO
     1    ,TRO2,TFO2,TSO2,G,THRD,TWN7,R2T,RA20,RA23,ONEOA,ONEOD
     1,TSFO2
      COMMON/SPLTAX/ SPSR3,SPSR4,IAX
      COMMON/CACATO/EPSK1,EPSK2,FEE1,FEE2,THE1,THE2
      COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI,PO,QO,RO,UO,VO,WO,XO,
     1    YO,ZO,THEO,PHIO,PSIO
      EQUIVALENCE
     1    (PARAM(34),CA0)     , (PARAM(35),CA1)    , (PARAM(36),CA2)    ,
     1    (PARAM(37),CA3)     , (PARAM(38),CA4)    , (PARAM(39),AISW)   ,
     1    (PARAM(85),B1)      , (PARAM(86),B2)     , (PARAM(87),B3),
     1 (PARAM(88),B4),          (PARAM( 89),DEL1DN),(PARAM( 90),DEL2DN),
     1 (PARAM(242),AKCF),(PARAM(243),AKCR),(PARAM(244),AKSR) ,
     1    (PARAM(290),ROT),(PARAM(291),RA0),(PARAM(292),RA1),
     1    (PARAM(293),RA2),(PARAM(294),RA3),(PARAM(295),RA4)
      EQUIVALENCE (PARAM(245),RB1),(PARAM(246),RB2)
     1,             (PARAM(247),RB3),(PARAM(248),RB4)
      EQUIVALENCE (FEE1,FEE(1)),(FEE2,FEE(2))
```

```
      EQUIVALENCE (PARAM(182),SII(1))
      REAL*4 SII(4)
      REAL*4 FEE(2)
      DO 60 K=1,2
      KK = K + 2
      AMUI(K)=(B1*FRI(K)+B2*CVI(K)+B3+B4*FRI(K)*FRI(K))*SNI(K)
      RMI(K) = FRI(K) * AMUI(K)
      FRIBR(K) = AMIN(FRI(K),A2T)
C     ALFI IS THE DENOMINATOR FOR THE BETA BAR CALCULATION
      ALFI(K) = CA1*FRIBR(K)*(FRIBR(K) - CA2) - CA20
      IF(ALFI(K)/CA2.GE.0.) ALFI(K) =-1.0E-10
      PHICGI(K) = THE*SINPSI(K) + PHI*COSPSI(K) + PHII(K)
     1 + AKCF*FSI(K)
C     FOR SOLID FRONT AXLE FEE1 AND FEE2 ARE USED FOR CONSTANT CAMBER
      IF(IAX.EQ.0) PHICGI(K) = FEE(K)
      BETIP(K) = CA23*(CA4-FRIBR(K))*FRIBR(K)*PHICGI(K)/(CA4*ALFI(K))
      IF(RMI(K).EQ.0.) GO TO 610
      BETIBR(K) = ALFI(K)*(BETAI(K) + BETIP(K))/(CA2*RMI(K))
      GO TO 710
  610 BETIBR(K) = 0.
  710 CONTINUE
      AMUI(KK) = (RB3 + RB1*FRI(KK) + RB2*CVI(KK) + RB4*FRI(KK)*FRI(KK))
     1 *SNI(KK)
      RMI(KK) = FRI(KK) * AMUI(KK)
      FRIBR(KK) = AMIN(FRI(KK),R2T)
      ALFI(KK) = RA1*FRIBR(KK)*(FRIBR(KK) - RA2) - RA20
      IF(ALFI(KK)/RA2.GE.0.) ALFI(KK) = 1.0E-10
      PHICGI(KK) = THE*SINPSI(KK) + PHI*COSPSI(KK) + PHII(KK)
     1 + AKCR*FSI(KK)
      IF(IAX.LE.1) PHICGI(KK)=0.
      BETIP(KK)=RA23*(RA4-FRIBR(KK))*FRIBR(KK)*PHICGI(KK)/(RA4*ALFI(KK))
      IF(RMI(KK).EQ.0.) GO TO 630
      BETIBR(KK) = ALFI(KK)*(BETAI(KK) + BETIP(KK)) / (RA2*RMI(KK))
      GO TO 730
  630 BETIBR(KK) = 0.
  730 CONTINUE
   60 CONTINUE
      DO 11 K=1,4
      ABI(K) = ABS(BETIBR(K))
      IF(ABI(K).GE.3.) GO TO 10
      GBI(K) = BETIBR(K)*(1.-THRD*ABI(K)+TWN7*BETIBR(K)**2)
      GO TO 80
   10 GBI(K) = BETIBR(K)/ABI(K)
   80 CONTINUE
C
C FUNCTION:  FCSI-SIDE FORCE SHAPING AS A FUNCTION OF SLIP
C
C INPUTS:    SAMI- SIDE-SLIP ANGLE (DEGREES)
C            GAMF-SIDE FORCE SHAPING FUNCTION AS A FUNCTION OF
C            SLIP (UNITY)
C            AFA-BRAKING SLIP (UNITY)
C            NFA-NUMBER OF DATA POINTS
C
C OUTPUTS:   FCSI-LINEARLY ITERPOLATED SIDE FORCE SHAPING FUNCTION
C
      BAMI(K) = BETAI(K) + BETIP(K)
      SAMI(K) = BAMI(K)*57.29578
       FI(K) = FCSI(SAMI(K),SLIPI(K))
      XX = ABS(AMUI(K)*GBI(K))
      ASNBET = ABS(SIN(BETAI(K)))*SNI(K)
```

```
      GO TO (100,100,110,110),K                                         LFRI1140
  100 XXX = (XX - (XX-PARAM(206)*ASNBET)*FI(K))*SIGN(1.,GBI(K))         LFRI1150
      GO TO 120                                                         LFRI1160
  110 XXX = (XX - (XX-PARAM(207)*ASNBET)*FI(K))*SIGN(1.,GBI(K))         LFRI1170
  120 CONTINUE                                                          LFRI1180
C           PARAM(306) TO (309) CIRCUM. FRICTION COEF.                  LFRI1190
      FSI(K) = FRI(K) * XXX                                             LFRI1200
      GI(K) = - PHI - PARAM(K + 305)*SINPSI(K) + XXX * COSPSI(K)        LFRI1210
      FYUI(K) = FRI(K)*GI(K)                                            LFRI1220
      FXUI(K)= FRI(K)*(THE-PARAM(K+305)*COSPSI(K) - XXX*SINPSI(K) )     LFRI1230
      FCI(K) =-FRI(K)*PARAM(K+305)                                      LFRI1240
      FCIMAX(K) =-FRI(K)*AM1I(K)*STI(K)                                 LFRI1250
   11 CONTINUE                                                          LFRI1260
      RETURN                                                            LFRI1270
      END                                                               LFRI1280
```

2.1.9 CFRIC

PRESENTED HERE IS THE FORTRAN LISTING FOR THE CFRIC SUBPROGRAM. CALCULATION OF THE CIRCUMFERENTIAL FRICTION COEFFICIENT IS PERFORMED IN THIS SUBPROGRAM.

```
C     SUBROUTINE CFRIC
      SUBROUTINE CFRIC
C*****************************************************************************
C     THIS SUBPROGRAM CALCULATES THE CIRCUMFERENTIAL FRICTION
C     COEFFICIENT
C*****************************************************************************
C             MUP- PEAK BRAKING COEF. CF FRICTION
C             MUS- SLIDING COEF. OF FRICTION
C             SII- SLIP RATIO AT WHICH PEAK BRAKING
C                  COEF. OF FRICTION OCCURS
C
C             SNI- RATIO OF SIM. VEHICLE SKID NUMBER SURFACE
C                   TO TIRE DATA SKID NUMBER SURFACE
C
C FUNCTION:    AM1I-RISE SLOPE OF UXI VS. WHEEL SLIP
C
C             SAMI- SLIP ANGLE (DEGREES)
C             SI1-(PARAM(182),UNITY)
C             SI2-(PARAM(183),UNITY)
C             SI3-(PARAM(184),UNITY)
C             SI4-(PARAM(185),UNITY)
C
C             OUTPUT:    AM1I - UNITY
      COMMON/PAUL/ D1,D2,D3,D4,SFYU,TMP,SNPHIU,SNTHEU,SNPSIU,
     1QDT,PDT, RDT ,UDT,VDT,WDT,PHIDT,THEDT,PSIDT,XDT,YDT,ZDT,
     1 AKK1,AKK2,                              THS1,THS2,
     1AMT1,AMT2,SN,SFXU,ETVDT,ETAX,ETAL,
     1 ZIP(4),PHII(4),
     1        U1I(4),BAMI(4),MUP(4),SAMI(4),FI(4),FXUI(4),FYUI(4),GI(4),
     1        ALFI(4),BETIP(4),BETIBR(4),SLIPI(4),AM1I(4),AM2I(4),UOI(4),
     1        FCI(4),FCIMAX(4),FSI(4),
     1        ABI(4),BETAI(4),AMUI(4),SNI(4),RMI(4),GBI(4),FRIBR(4),
     1        RWZI(4),ZI(4),FRI(4),          UI(4),VI(4),WI(4),UGI(4),
     1        VGI(4),SINPSI(4),PSII(4),COSPSI(4),UGIP(4),PHICGI(4),CVI(4)
     1,ALTQ(4),OTM(4),SALTQ,FOTM,ROTM
     1,AP1,AP2,AP3,AP4,AR1,AR2,AR3,AR4,ANTI1,ANTI2,ANTI3,ANTI4
     1,DLIS(4),ZIMX(4),FES1,FES2,FES3,FBS4
     1,PHIDMX
      COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI,PO,QO,RO,UO,VO,WO,XO,
     1    YO,ZO,THEO,PHIO,PSIO
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      REAL*4 MUSF,MUSR
      REAL*4 MUS(2),APF(2),APR(2),IOUT(48),MUP,SII(4)
      EQUIVALENCE (PARAM(182),SII(1)),(PARAM(324),IOUT(1))
      EQUIVALENCE (PARAM(202),APF(1)),(PARAM(204),APR(1)),
     1   (PARAM(206),MUS(1))
      EQUIVALENCE  (APF(1),APF1),(APR(1),APR1),
     1             (APF(2),APF2),(APR(2),APR2)
      EQUIVALENCE (BCON,PARAM(208))
      DO 13 K=1,2
      KK=K+2
      MUP(K) = APF1 + APF2*FRI(K)
      MUSF = MUS(1)*ABS(COS(BETAI(K)))
      AM1I(K) = (MUP(K)/SII(K))*(1. -BCON*ABS(SAMI(K)))
C **  MUS(1) EQUALS MUSF,MUS(2) EQUALS MUSR **
      IF((AM1I(K))*SII(K).LT.MUSF) AM1I(K) = MUSF/SII(K)
      IF(SLIPI(K).GT.SII(K)) GO TO 71
      AM1I(K) = AM1I(K) * SNI(K)
C     MDACS 22,23 ARE USED TO OUTPUT FRONT SLOPES, & 20,21 FOR REAR
```

```
C     DACS 32 TO 35 ARE USED TO OUTPUT THE INTERCEPTS
      IOUT(K+22) = AM1I(K)
      IOUT(K+32) = 0.
      GO TO 72
 71    CONTINUE
      AM2I(K) =  (MUSF-(AM1I(K)*SII(K)))/(1. - SII(K))
      AM2I(K) = AM2I(K) * SNI(K)
      IOUT(K+22) = AM2I(K)
C OUTPUT:      U1I-VALUE OF UXI AT BRAKE SLIP = 1. (UNITY)
      U1I(K) = MUSF   * SNI(K)
C OUTPUT:      U0I-INTERCEPT OF UXI AT BRAKE SLIP = 0 (UNITY)
      U0I(K) = U1I(K) - AM2I(K)
      IOUT(K+32) = U0I(K)
 72    CONTINUE
      MUP(KK) = APR1 + APR2 * FRI(KK)
      MUSR = MUS(2)*ABS(COS(BETAI(KK)))
      AM1I(KK) = (MUP(KK)/SII(KK))*(1. - BCON*ABS(SAMI(KK)))
      IF((AM1I(KK))*SII(KK).LT.MUSR) AM1I(KK) = MUSR/SII(KK)
      IF(SLIPI(KK).GT.SII(KK)) GO TO 76
      AM1I(KK) = AM1I(KK) * SNI(KK)
      IOUT(KK+18) = AM1I(KK)
      IOUT(KK+32) = 0.
      GO TO 77
 76    CONTINUE
      AM2I(KK)= (MUSR - (AM1I(KK)*SII(KK)))/(1. - SII(KK))
      AM2I(KK) = AM2I(KK) * SNI(KK)
      IOUT(KK+18) = AM2I(KK)
      U1I(KK) = MUSR    * SNI(KK)
      U0I(KK) = U1I(KK) - AM2I(KK)
      IOUT(KK+32) = U0I(KK)
 77    CONTINUE
  13  CONTINUE
      RETURN
      END
```

2.1.10 DUAL

PRESENTED HERE IS THE FORTRAN LISTING FOR THE DUAL TIRE SUBPROGRAM. CALCULATION OF DUAL REAR TIRE DIGITAL MODEL EQUATIONS IS PERFORMED IN THIS SUBPROGRAM.

```
C     SUBROUTINE DUAL
      SUBROUTINE DUAL
C*****************************************************************************
C     THIS SUBPROGRAM CALCULATES THE DUAL REAR TIRE DIGITAL MODEL
C     EQUATIONS
C*****************************************************************************
      COMMON/DULVAR/Z3ID,Z4ID,Z5OD,Z6OD,
     1              F3RID,F4RID,F5ROD,F6ROD,
     1              U3ID,U4ID,U5OD,U6OD,
     1              V3ID,V4ID,V5OD,V6OD,
     1              W3ID,W4ID,W5OD,W6OD,
     1              UG3ID,UG4ID,UG5OD,UG6OD,
     1              VG3ID,VG4ID,VG5OD,VG6OD,
     1              UG3IDP,UG4IDP,UG5ODP,UG6ODP,
     1              S3ID,S4ID,S5OD,S6OD,
     1              CF3ID,CF4ID,CF5OD,CF6OD,
     1              AMUI3,AMUI4,AMUI5,AMUI6,
     1              ALTQ3P,ALTQ4P,
     1              OTM3P,OTM4P,OTM5,OTM6
      COMMON/DUALS/IDULTR,NWHEEL,TIRO2,TORO2,TIRTOR,VBRZRP,
     1 FXU5,FXU6,FYU5,FYU6,ALTQ5,ALTQ6,PSI3,PSI4,PSI5,PSI6,PPHIR
      COMMON/XBS/XB(30),NS(4,30),DELX(4),XI(4),NNN
      COMMON/PAUL/ D1,D2,D3,D4,SFYU,TMP,SNPHIU,SNTHEU,SNPSIU,
     1QDT,PDT, RDT ,UDT,VDT,WDT,PHIDT,THEDT,PSIDT,XDT,YDT,ZDT,
     1 AKK1,AKK2,                           THS1,THS2,
     1AMT1,AMT2,SN,SFXU,BTVDT,ETAX,ETAL,
     1 ZIP(4),PHII(4),
     1      U1I(4),BAMI(4),MUP(4),SAMI(4),FI(4),FXUI(4),FYUI(4),GI(4),
     1      ALFI(4),BETIP(4),BETIBR(4),SLIPI(4),AM1I(4),AM2I(4),UOI(4),
     1      FCI(4),FCIMAX(4),FSI(4),
     1      ABI(4),BETAI(4),AMUI(4),SNI(4),RMI(4),GBI(4),FRIBR(4),
     1      RWZI(4),ZI(4),FRI(4),        UI(4),VI(4),WI(4),UGI(4),
     1      VGI(4),SINPSI(4),PSII(4),COSPSI(4),UGIP(4),PHICGI(4),CVI(4)
     1,ALTQ(4),OTM(4),SALTQ,FOTM,BOTM
     1,AP1,AP2,AP3,AP4,AR1,AR2,AR3,AR4,ANTI1,ANTI2,ANTI3,ANTI4
     1,DLIS(4),ZIMX(4),FBS1,FBS2,FBS3,FBS4
     1,PHIDMX
      COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI,PO,QO,RO,UO,VO,WO,XO,
     1    YO,ZO,THEO,PHIO,PSIO
      COMMON/COMBLK/AIXP,SM,AIYP,AIXZP,GAM1,GAM2,GAM3,AIXBR,AIYBR,
     1    AIZBR,A1,A2,AIXZBR,A12,E1,E2,E3,DELTA,GV1,GV2,GP1,GP2,GR1,
     1    GR2,CIP,CIVP,RZF,RZR,A2T,CA20,CA23,             ANGNL,ANGNLO
     1    ,TRO2,TFO2,TSO2,G,THRD,TWN7,R2T,RA20,RA23,ONEOA,ONEOD
     1,TSFO2
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      REAL*4 AKTI(4),IOUT(48)
      EQUIVALENCE
     1(PARAM(31),RW),
     1(PARAM(79),AKTI(3)),(PARAM(80),AKTI(4)),
     1(PARAM(245),RB1),(PARAM(246),RB2),
     1(PARAM(247),RB3),(PARAM(248),RB4),
     1(PARAM(252),ARK1),(PARAM(253),ARK2),(PARAM(254),ARK3),
     1(PARAM(259),ORC0),(PARAM(260),ORC1),(PARAM(261),ORC2),
     1(PARAM(262),ORC3),(PARAM(303),PHIR),
     1(PARAM(318),ARPS3),(PARAM(319),ARPS4),(PARAM(324),IOUT(1))
      Z3ID=ZI(3)+TIRTOR*(PHI+PHIR)
      Z4ID=ZI(4)-TIRTOR*(PHI+PHIR)
      Z5OD=ZI(3)-TIRTOR*(PHI+PHIR)
      Z6OD=ZI(4)+TIRTOR*(PHI+PHIR)
```

```
      F3RID = AKTI(3)*(RW+Z3ID -DELX(3))
      F4RID = AKTI(4)*(RW+Z4ID -DELX(4))
      F5ROD = AKTI(3)*(RW+Z5OD -DELX(3))
      F6ROD = AKTI(4)*(RW+Z6OD -DELX(4))
      IF(F3RID.LT.0.) F3RID=0.0
      IF(F4RID.LT.0.) F4RID=0.0
      IF(F5ROD.LT.0.) F5ROD=0.0
      IF(F6ROD.LT.0.) F6ROD=0.0
      U3ID=UI(3)-TIRTOR*R
      U4ID=UI(4)+TIRTOR*R
      U5OD=UI(3)+TIRTOR*R
      U6OD=UI(4)-TIRTOR*R
      V3ID = VBRZRP + Z3ID*PPHIR
      V4ID = VBRZRP + Z4ID*PPHIR
      V5OD = VBRZRP + Z5OD*PPHIR
      V6OD = VBRZRP + Z6OD*PPHIR
      W3ID=WI(3)+TIRTOR*PPHIR
      W4ID=WI(4)-TIRTOR*PPHIR
      W5OD=WI(3)-TIRTOR*PPHIR
      W6OD=WI(4)+TIRTOR*PPHIR
      UG3ID = U3ID + THE*W3ID
      UG4ID = U4ID + THE*W4ID
      UG5OD = U5OD + THE*W5OD
      UG6OD = U6OD + THE*W6OD
      VG3ID = V3ID - PHI*W3ID
      VG4ID = V4ID - PHI*W4ID
      VG5OD = V5OD - PHI*W5OD
      VG6OD = V6OD - PHI*W6OD
      UG3IDP = UG3ID*COSPSI(3) + VG3ID*SINPSI(3)
      UG4IDP = UG4ID*COSPSI(4) + VG4ID*SINPSI(4)
      UG5ODP = UG5OD*COSPSI(3) + VG5OD*SINPSI(3)
      UG6ODP = UG6OD*COSPSI(4) + VG6OD*SINPSI(4)
      S3ID = 1. + (ARPS3*Z3ID)/UG3IDP
      IF(S3ID.LT.(-1.).OR.S3ID.GT.1.) S3ID = SIGN(1.,S3ID)
      S4ID = 1. + (ARPS4*Z4ID)/UG4IDP
      IF(S4ID.LT.(-1.).OR.S4ID.GT.1.) S4ID = SIGN(1.,S4ID)
      S5OD = 1. + (ARPS3*Z5OD)/UG5ODP
      IF(S5OD.LT.(-1.).OR.S5OD.GT.1.) S5OD = SIGN(1.,S5OD)
      S6OD = 1. + (ARPS4*Z6OD)/UG6ODP
      IF(S6OD.LT.(-1.).OR.S6OD.GT.1.) S6OD = SIGN(1.,S6OD)
      CF3ID = IOUT(35) + S3ID*IOUT(21)
      CF4ID = IOUT(36) + S4ID*IOUT(22)
      CF5OD = IOUT(35) + S5OD*IOUT(21)
      CF6OD = IOUT(36) + S6OD*IOUT(22)
      AMUI3 = (RB3 + RB1*F3RID + RB4*F3RID*F3RID)* SNI(3)
      AMUI4 = (RB3 + RB1*F4RID + RB4*F4RID*F4RID)* SNI(4)
      AMUI5 = (RB3 + RB1*F5ROD + RB4*F5ROD*F5ROD)* SNI(3)
      AMUI6 = (RB3 + RB1*F6ROD + RB4*F6ROD*F6ROD)* SNI(4)
      XX3=ABS(AMUI3*GBI(3))
      XX4=ABS(AMUI4*GBI(4))
      XX5=ABS(AMUI5*GBI(3))
      XX6=ABS(AMUI6*GBI(4))
      ASNBT4=ABS(SIN(BETAI(4)))*SNI(4)*PARAM(207)
      ASNBT3=ABS(SIN(BETAI(3)))*SNI(3)*PARAM(207)
      SIGNB3=SIGN(1.,GBI(3))
      SIGNB4=SIGN(1.,GBI(4))
      XXX3=(XX3-(XX3-ASNBT3)*FI(3))*SIGNB3
      XXX4=(XX4-(XX4-ASNBT4)*FI(4))*SIGNB4
      XXX5=(XX5-(XX5-ASNBT3)*FI(3))*SIGNB3
      XXX6=(XX6-(XX6-ASNBT4)*FI(4))*SIGNB4
```

```
      FYUI(3)=F3RID*(-PHI-CF3ID*SINPSI(3)+             COSPSI(3)*XXX3)
      FYUI(4)=F4RID*(-PHI-CF4ID*SINPSI(4)+             COSPSI(4)*XXX4)
      FYU5 = F5ROD*(-PHI-CF5OD*SINPSI(3)+              COSPSI(3)*XXX5)
      FYU6 = F6ROD*(-PHI-CF6OD*SINPSI(4)+              COSPSI(4)*XXX6)
      FSI3 = F3RID*XXX3
      FSI4 = F4RID*XXX4
      FSI5 = F5ROD*XXX5
      FSI6 = F6ROD*XXX6
      FXUI(3)=F3RID*(THE-CF3ID*COSPSI(3)-             SINPSI(3)*XXX3)
      FXUI(4)=F4RID*(THE-CF4ID*COSPSI(4)-              SINPSI(4)*XXX4)
      FXU5 = F5ROD*(THE-CF5OD*COSPSI(3)  -            SINPSI(3)*XXX5 )
      FXU6 = F6ROD*(THE-CF6OD*COSPSI(4)  -             SINPSI(4)*XXX6)
C       PHICG3=PHICG4=PHICG5=PHICG6=0.0
      ALTQ3P=ARK1*F3RID*FSI3+SIGN(1.,FSI3)*FSI3*FSI3*ARK2
      ALTQ4P=ARK1*F4RID*FSI4+SIGN(1.,FSI4)*FSI4*FSI4*ARK2
      ALTQ5=ARK1*F5ROD*FSI5+SIGN(1.,FSI5)*FSI5*FSI5*ARK2
      ALTQ6=ARK1*F6ROD*FSI6+SIGN(1.,FSI6)*FSI6*FSI6*ARK2
      ALTQ(3) = (ALTQ3P+ALTQ5)
      ALTQ(4) = (ALTQ4P+ALTQ6)
      OTM3P=F3RID*ORC1*FSI3
      OTM4P=F4RID*ORC1*FSI4
      OTM5= F5ROD*ORC1*FSI5
      OTM6= F6ROD*ORC1*FSI6
      OTM(3) = (OTM3P+OTM5)
      OTM(4) = (OTM4P+OTM6)
      RETURN
      END
```

2.1.11 AERODY

PRESENTED HERE IS THE FORTRAN LISTING FOR THE AERODYNAMIC SUBPROGRAM. CALCULATION OF THE AERODYNAMIC FORCES AND MOMENTS IS PERFORMED IN THIS SUBPROGRAM.

```
C     SUBROUTINE AERODY
      SUBROUTINE AERODY
C***********************************************************************
C     THIS SUBPROGRAM CALCULATES THE AERODYNAMIC FORCES AND MOMENTS
C     WHICH ACT DIRECTLY ON THE SPRUNG MASS
C***********************************************************************
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI,PO,QO,RO,UO,VO,WO,XO,
     1    YO,ZO,THEO,PHIO,PSIO
      COMMON/AERVAR/UR,VR,WR,PBAR,QBAR,RBAR,VCW,ALPHAC,TAUC,QA,QASF,
     1              CXC,CYC,CZC,CLC,CMC,CNC,DELCXC
      COMMON/AERO/SFXS,SFYS,SFZS,SNTHES,SNPHIS,SNPSIS,APLUSB,IAERO
      COMMON/AROTBS/ TAU(20),CX(20),CY(20),CZ(20),CL(20),
     1CM(20),CN(20), ALPHA(20),DELCX(20),NCX,NCY,NCZ,
     1NCL,NCM,NCN,NDCX,XWP(20),VYWTB(20),NWP
      EQUIVALENCE
     1                        (PARAM(142),VYW),(PARAM(143),OMXW),
     1   (PARAM(144),OMZW),(PARAM(145),RHOA),(PARAM(146),CYP),
     1   (PARAM(147),CYR),(PARAM(148),CZAL),(PARAM(149),CZQ),
     1   (PARAM(150),CLP),(PARAM(151),CLR),(PARAM(152),CMAL),
     1   (PARAM(153),CMQ),(PARAM(154),CNP),(PARAM(155),CNR),
     1   (PARAM(156),SF) , (PARAM(157),VL) , (PARAM(158),RWV)
      EQUIVALENCE (PARAM(06),A) , (PARAM(07),B) ,(PARAM(71),HCG)
      WBL=A+B
      DCG=A-WBL/2.
C     CROSS WIND DISTURBANCE
      VYW=0.0
      IF((X.LT.XWP(1)).OR.(X.GT.XWP(NWP)))GO TO 100
      VYW=XINT(X,XWP,VYWTB,NWP)
100   CONTINUE
      UR = U -VYW*SIN(PSI)
      VR = V -VYW*COS(PSI)
      WR = W
      PBAR = (P - OMXW*COS(PSI) + OMZW*THE)* APLUSB/UR
      QBAR = (Q + OMXW*SIN(PSI) - OMZW*PHI) * APLUSB/UR
      RBAR = (R - OMZW)* APLUSB/UR
      VCW =  SQRT(UR*UR + VR*VR + WR*WR)
      ALPHAC = ATAN(WR/UR)
      TAUC=ABS(ARSIN(VR/VCW))
      QA     = (RHOA * VCW*VCW)/2.
      CXC = XINT(TAUC,TAU,CX,NCX)
      CYC = XINT(TAUC,TAU,CY,NCY)
      CZC = XINT(TAUC,TAU,CZ,NCZ)
      CLC = XINT(TAUC,TAU,CL,NCL)
      CMC = XINT(TAUC,TAU,CM,NCM)
      CNC = XINT(TAUC,TAU,CN,NCN)
      DELCXC = XINT(ALPHAC,ALPHA,DELCX,NDCX)
C     AERODYNAMIC FORCES AND MOMENTS
      QASF = QA*SF
      SFXS = (CXC + DELCXC) * QASF
      SFXS=-SFXS
      SFYS = (CYC + CYP*PBAR + CYR*RBAR) * QASF
      SFZS = (CZC + CZAL*ALPHAC + CZQ*QBAR) * QASF
      SFZS=-SFZS
      SNPHIS=(VL*CLC+HCG*CYC)*QASF
      SNTHES=(VL*CMC+DCG*CZC+HCG*CXC)*QASF
      SNPSIS=(VL*CNC+DCG*CYC)*QASF
      RETURN
      END
```

2.1.12 NTEGRT

PRESENTED HERE IS THE FORTRAN LISTING FOR THE INTEGRATION SUBPROGRAM. INTEGRATION OF THE KINEMATIC VARIABLES IS PERFORMED IN THIS SUBPROGRAM.

```
C     SUBROUTINE NIEGRT
      SUBROUTINE NTEGRT(*)
C***********************************************************************
C     THIS SUBROUTINE PERFORMS THE INTEGRATION OF THE KINEMATIC VARIABLE
C***********************************************************************
      COMMON/SWITCH/ ISW
      COMMON/OUTVAR/ POUT,QOUT,ROUT,UOUT,VOUT,WOUT,XOUT,YOUT,ZOUT,
     1PDTOUT,QDTOUT,RDTOUT,THEOUT,PHIOUT,PSIOUT,UDTOUT,VDTOUT,WDTOUT
      COMMON/PAUL/ D1,D2,D3,D4,SFYU,TMP,SNPHIU,SNTHEU,SNPSIU,
     1QDT,PDT, RDT ,UDT,VDT,WDT,PHIDT,THEDT,PSIDT,XDT,YDT,ZDT,
     1 AKK1,AKK2,                                THS1,THS2,
     1AMT1,AMT2,SN,SFXU,BTVDT,ETAX,ETAL,
     1 ZIP(4),PHII(4),
     1        U1I(4),BAMI(4),MUP(4),SAMI(4),FI(4),FXUI(4),FYUI(4),GI(4),
     1        ALFI(4),BETIP(4),BETIBR(4),SLIPI(4),AM1I(4),AM2I(4),UOI(4),
     1        FCI(4),FCIMAX(4),FSI(4),
     1        ABI(4),BETAI(4),AMUI(4),SNI(4),RMI(4),GBI(4),FRIBR(4),
     1        RWZT(4),ZI(4),FRI(4),         UI(4),VI(4),WI(4),UGI(4),
     1        VGI(4),SINPSI(4),PSII(4),COSPSI(4),UGIP(4),PHICGI(4),CVI(4)
     1,ALTQ(4),OTM(4),SALTQ,FOTM,ROTM
     1,AP1,AP2,AP3,AP4,AR1,AR2,AR3,AR4,ANTI1,ANTI2,ANTI3,ANTI4
     1,DLIS(4),ZIMX(4),FBS1,FBS2,FBS3,FBS4
     1,PHIDMX
      COMMON/EFFS/ANUM,ADEN,ANUMDT,ADENDT,ANUMO,ADENO,ANUMDO,ADENDO,
     1   ANOUT,ADOUT
      COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI,PO,QO,RO,UO,VO,WO,XO,
     1    YO,ZO,THEO,PHIO,PSIO
      COMMON/TIMBLK/JJTIME,TIME,DT
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      GO TO (1100,1200,3000), ISW
 1100 CONTINUE
      IF(PARAM(180).EQ.1)
     1GO TO 99100
      U = UO+UDT*DT
      V=VO+VDT*DT
      W=WO+WDT*DT
      P=PO+PDT*DT
      Q=QO+QDT*DT
      R=RO+RDT*DT
      X=XO+XDT*DT
      Y=YO+YDT*DT
      Z=ZO+ZDT*DT
      PHI=PHIO+PHIDT*DT
      THE=THEO+THEDT*DT
      PSI=PSIO+PSIDT*DT
      ANUM=ANUMO+ANUMDT*DT
      ADEN=ADENO+ADENDT*DT
99100 CONTINUE
      UDTO=UDT
      VDTO=VDT
      WDTO=WDT
      PDTO=PDT
      QDTO=QDT
      RDTO=RDT
      PHIDTO=PHIDT
      THEDTO=THEDT
      PSIDTO=PSIDT
      XDTO=XDT
      YDTO=YDT
```

```
      ZDTO=ZDT
      ANUMDO=ANUMDT
      ADENDO=ADENDT
      IF(PARAM(180).EQ.1.)
     1GO TO 1200
      ISW=2
      RETURN 1
 1200 TLT=0.5*DT
      V=VO+TLT*(VDT+VDTO)
      W=WO+TLT*(WDT+WDTO)
      P=PO+TLT*(PDT+PDTO)
      Q=QO+TLT*(QDT+QDTO)
      R=RO+TLT*(RDT+RDTO)
      X=XO+TLT*(XDT+XDTO)
      Y=YO+TLT*(YDT+YDTO)
      Z=ZO+TLT*(ZDT+ZDTO)
      PHI=PHIO+TLT*(PHIDT+PHIDTO)
      THE=THEO+TLT*(THEDT+THEDTO)
      PSI=PSIO+TLT*(PSIDT+PSIDTO)
      U=UO+TLT*(UDT+UDTO)
      ANUM=ANUMO+TLT*(ANUMDT+ANUMDO)
      ADEN=ADENO+TLT*(ADENDT+ADENDO)
      PHIOUT=PHI
      THEOUT=THE
      POUT=P
      QOUT=Q
      ROUT=R
      UOUT=U
      VOUT=V
      WOUT=W
      XOUT=X
      YOUT=Y
      ZOUT=Z
      PDTOUT=0.5*(PDT+PDTO)
      QDTOUT=0.5*(QDT+QDTO)
      RDTOUT=0.5*(RDT+RDTO)
      PSIOUT=PSI
      UDTOUT=0.5*(UDT+UDTO)
      VDTOUT=.5*(VDT+VDTO)
      WDTOUT=0.5*(WDT+WDTO)
      ANOUT=ANUM
      ADOUT=ADEN
      PO=P
      QO=Q
      RO=R
      UO=U
      VO=V
      WO=W
      XO=X
      YO=Y
      ZO=Z
      PHIO=PHI
      THEO=THE
      PSIO=PSI
      ANUMO=ANUM
      ADENO=ADEN
3000  CONTINUE
99120 CONTINUE
      RETURN
      END
```

2.1.13 STRBRK

PRESENTED HERE IS THE FORTRAN LISTING FOR THE STEER AND BRAKE SUBPROGRAM. CALCULATION OF THE STEERING AND BRAKING COMMANDS IS PERFORMED IN THIS SUBPROGRAM.

```
C     SUBROUTINE STRBRK
      SUBROUTINE STRBRK
C*****************************************************************************
C     STEERING AND BRAKING COMMANDS CALCULATED
C*****************************************************************************
      COMMON/PAUL/ D1,D2,D3,D4,SFYU,TMP,SNPHIU,SNTHEU,SNPSIU,
     1QDT,PDT, RDT ,UDT,VDT,WDT,PHIDT,THEDT,PSIDT,XDT,YDT,ZDT,
     1 AKK1,AKK2,                         THS1,THS2,
     1AMT1,AMT2,SN,SFXU,ETVDT,ETAX,ETAL,
     1 ZIP(4),PHII(4),
     1       U1I(4),BAMI(4),MUP(4),SAMI(4),FI(4),FXUI(4),FYUI(4),GI(4),
     1       ALFI(4),BETIP(4),BETIBR(4),SLIPI(4),AM1I(4),AM2I(4),UOI(4),
     1       FCI(4),FCIMAX(4),FSI(4),
     1       ABI(4),BETAI(4),AMUI(4),SNI(4),RMI(4),GBI(4),FRIBR(4),
     1       RWZI(4),ZI(4),FRI(4),       UI(4),VI(4),WI(4),UGI(4),
     1       VGI(4),SINPSI(4),PSII(4),COSPSI(4),UGIP(4),PHICGI(4),CVI(4)
     1,ALTQ(4),OTM(4),SALTQ,FOTM,ROTM
     1,AP1,AP2,AP3,AP4,AR1,AR2,AR3,AR4,ANTI1,ANTI2,ANTI3,ANTI4
     1,DLIS(4),ZIMX(4),FBS1,FBS2,FBS3,FBS4
     1,PHIDMX
      COMMON/OUTVAR/ POUT,QOUT,ROUT,UOUT,VOUT,WOUT,XOUT,YOUT,ZOUT,
     1PDTOUT,QDTOUT,RDTOUT,THEOUT,PHIOUT,PSIOUT,UDTOUT,VDTOUT,WDTOUT
      COMMON/THINGS/TMAX1,TMAX2,TMAX3,TQRMAX,TQFMAX,PSIMAX,ONER
      COMMON/DELS/DELSWC
      COMMON/UVW/VC,UIN
      COMMON/ZILCH/TQMAXF,TQMAXR,AKTQF,AKTQR,TQDRF,TQDRR,IDRSW
      COMMON/TIMBLK/JJTIME,TIME,DT
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      COMMON/NEWER/TIME25,TIME10,PSI5,PHIMAX,DSWMAX
      DATA RAD/0.1745329E-1/
      EQUIVALENCE (PARAM(118),CS),(PARAM(123),DSW),(PARAM(121),PFL),
     1            (PARAM(117),CGAM),(PARAM(55),PTBR),(PARAM(62),ARFBR),
     1            (PARAM(122),TTD),(PARAM(124),TSW),(PARAM(115),TST),
     1            (PARAM(119),TQRBR),(PARAM(233),ALAMBD)
      EQUIVALENCE (TQFBR,PARAM(120)),(DSWCM,PARAM(114))
      EQUIVALENCE  (PARAM(108),FREQ)
      DSLM=PARAM(114)/PARAM(116)
      XTMP=PARAM(121)/PARAM(192)
      IF(PARAM(126).NE.0.0)GO TO 4321
      IF(TIME.GT.TST)GO TO 6000
      DELSWC=0.0
      GO TO 7000
 6000 DELSWC=(TIME-TST)*DSLM
      IF(ABS(DELSWC).GT.DSWCM)DELSWC=DSWCM*SIGN(1.0,DELSWC)
      IF(PARAM(128).EQ.3.0)GO TO 7000
      IF( TIME.GT.4.5 )DELSWC=DSWCM*(5.5-TIME)*SIGN(1.0,DELSWC)
 7000 DELSWC=DELSWC*RAD
      PF=0.0
      IF(TIME.LT.TTD)GO TO 4444
      PF=(TIME-CGAM)*XTMP
      IF(PARAM(128).EQ.1.0)GO TO 2223
      IF(PARAM(128).EQ.3.0)GO TO 2223
 2222 IF(PF.GT.PFL)PF=PFL
      IF(TIME.LT.CGAM)PF=0.0
      PFR=(TIME-CS)*XTMP
      IF( TIME.GT.CS )PF=PF*(CS-TIME)/10.
      IF(TIME.LT.CS)PFR=0.0
      IF(PFR.GT.PFL)PFR=PFL
      IF( TIME.GT.CS )PFR=PFR*(CS-TIME)/10.
```

```
C
C FUNCTION:  FF-FRONT WHEEL BRAKE TORQUE AS A FUNCTION OF FRONT
C            BRAKE LINE PRESSURE
C
C INPUTS:    PFR-FRONT WHEEL BRAKE LINE PRESSURE (PSI)
C            PBF-BRAKE LINE PRESSURE(PSI), ABSISSA USED IN LINEAR
C            INTERPOLATION SUBROUTINE
C            TQBF-FRONT WHEEL BRAKE TORQUE (INCH-POUNDS),ORDINATE USED
C            IN LINEAR INTERPOLATION SUBROUTINE
C
C OUTPUTS:   FF-INTERPOLATED FRONT WHEEL BRAKE TORQUE AS A FUNCTION
C            OF FRONT BRAKE LINE PRESSURE
C
      TQFBR =-FF(PF)
C
C FUNCTION:  FR-REAR WHEEL BRAKE TORQUE AS A FUNCITON OF REAR BRAKE
C            LINE PRESSURE
C
C INPUTS:    PFR-BRAKE LINE PRESSURE(PSI)
C            PBR-BRAKE LINE PRESSURE (PSI),ABSISSA
C            TQBR-REAR WHEEL BRAKE TORQUE (INCH-POUNDS),ORDINATE
C
C OUTPUT:    FR-INTERPOLATED REAR WHEEL BRAKE TORQUE AS A FUNCTION
C            OF REAR BRAKE LINE PRESSURE
C
      TQRBR = -FR(PFR)
      GO TO 2345
 2223 PF=(TIME-CGAM)*XTMP
      IF(PF.GT.PFL)PF=PFL
      PFR=(TIME-CGAM)*XTMP
      IF(PFR.GT.PFL)PFR=PFL
      TQFBR =-FF(PF)
      TQRBR = -FR(PFR)
      IF(TIME.LE.CGAM)TQFBR=0.
      IF(TIME.LE.CGAM)TQRBR=0.
      GO TO 2345
C        DRIVE TORQUE CALCULATIONS
C        IDRSW=0, REAR WHEEL DRIVE
C             =1, FOUR WHEEL DRIVE
 4444 TQFBR= 0.0
      TQRBR = 0.0
      IF(IDRSW.NE.1) GO TO 5555
      TQDRF=AKTQF*(VC-UOUT)
      IF(TQDRF.GE.TQMAXF) TQDRF=TQMAXF
      TQFBR = 0.5*(1.-ALAMBD)*ARFBR*TQDRF
 5555 TQDRR=AKTQR*(VC-UOUT)
      IF(TQDRR.GE.TQMAXR) TQDRR=TQMAXR
      TQRBR = 0.5*ALAMBD*TQDRR
      GO TO 2345
 4321 CONTINUE
      DELSWC=SIN(6.28*FREQ*TIME)*DSW*RAD
      IF(TIME.GT.1./FREQ)DELSWC=0.0
      IF((TIME.GT.0.5/FREQ).AND.(PARAM(129).GT.5.)) DELSWC = 0.0
      PF=0.0
      TQRBR=0.0
      TQFBR=0.0
      IF(PARAM(125).EQ.0.0)GO TO 2345
      IF(TIME.LE.PARAM(278).OR.TIME.GT.PARAM(279))GO TO 2345
      PF=(TIME-PARAM(278))*26000.0
      IF(PF.GT.PFL)PF=PFL
```

```
      TQFBR =-FF(PF)
      TQRBR = -FR(PF)
 2345 CONTINUE
      IF(PARAM(193).NE.0.0)DELSWC=0.01745329*(PARAM(194)*YOUT+PARAM(195)
     1      *YDT)
      TEMPE=ABS(DELSWC/RAD)
      IF(TEMPE.GT.DSWMAX)DSWMAX=TEMPE
      TEMPE=ABS(TQRBR)
      IF(TEMPE.GT.TQRMAX)TQRMAX=TEMPE
      TEMPE=ABS(TQFBR)
      IF(TEMPE.GT.TQFMAX)TQFMAX=TEMPE
      RETURN
      END
```

2.1.14 CVCALC

PRESENTED HERE IS THE FORTRAN LISTING FOR THE COMPARISON VARIABLE SUBPROGRAM. THIS SUBPROGRAM COLLECTS DATA FOR COMPARISON VARIABLE CALCULATION.

```
C     SUBROUTINE CVCALC
      SUBROUTINE CVCALC
C***********************************************************************
C     THIS SUBROUTINE COLLECTS DATA FOR COMPARISON VARIABLE CALCULATION
C***********************************************************************
      COMMON/OUTVAR/ POUT,QOUT,ROUT,UOUT,VOUT,WOUT,XOUT,YOUT,ZOUT,
     1PDTOUT,QDTOUT,RDTOUT,THEOUT,PHIOUT,PSIOUT,UDTOUT,VDTOUT,WDTOUT
      COMMON/EXTRA/ PSI3S,PSI4S,BTV,AYSTI
      COMMON/NEWER/TIME25,TIME10,PSI5,PHIMAX,DSWMAX
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      COMMON/TIMBLK/JJTIME,TIME,DT
      COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI,PO,QO,RO,UO,VO,WO,XO,
     1    YO,ZO,THEO,PHIO,PSIO
      COMMON/COMVAR/ AXAVE,CUVRAT,BETDMX,CURTBP,TIMDEC,JUMP,DELSTR,DEL,
     1                AXI,CURVAV,ABBTV,AYMAX,RMAX,DELBET,DELPSI,BETAMX,
     1                TIMBMP,GETDL,TIMIN5,          TSTEP ,   IVHTP
      COMMON/UVW/VC,UIN
      COMMON/PAUL/ D1,D2,D3,D4,SFYU,TMP,SNPHIU,SNTHEU,SNPSIU,
     1QDT,PDT, RDT ,UDT,VDT,WDT,PHIDT,THEDT,PSIDT,XDT,YDT,ZDT,
     1 AKK1,AKK2,                              THS1,THS2,
     1AMT1,AMT2,SN,SFXU,BTVDT,ETAX,ETAL,
     1 ZIP(4),PHIT(4),
     1      U1I(4),BAMI(4),MUP(4),SAMI(4),FI(4),FXUI(4),FYUI(4),GI(4),
     1      ALFI(4),BETIP(4),BETIBR(4),SLIPI(4),AM1I(4),AM2I(4),U0I(4),
     1      FCI(4),FCIMAX(4),FSI(4),
     1      ABI(4),BETAI(4),AMUI(4),SNI(4),RMI(4),GBI(4),FRIBR(4),
     1      RWZI(4),ZI(4),FRI(4),          UI(4),VI(4),WI(4),UGI(4),
     1      VGI(4),SINPSI(4),PSII(4),COSPSI(4),UGIP(4),PHICGI(4),CVI(4)
     1,ALTQ(4),OTM(4),SALTQ,POTM,ROTM
     1,AP1,AP2,AP3,AP4,AR1,AR2,AR3,AR4,ANTI1,ANTI2,ANTI3,ANTI4
     1,DLIS(4),ZIMX(4),FBS1,FBS2,FBS3,FBS4
     1,PHIDMX
      COMMON/THINGS/TMAX1,TMAX2,TMAX3,TQRMAX,TQFMAX,PSIMAX,ONER
      REAL*4 MPHIPS
      DATA MPHIPS/17.6/
      DATA RAD/0.1745329E-1/
      EQUIVALENCE (PARAM(123),DSW),(PARAM(115),TST),(PARAM(117),CGAM)
      EQUIVALENCE (PARAM(108),FREQ)
C     LONGITUDINAL AND LATERAL ACCELERATION CALCULATION
      ETAX=(UDTOUT-VOUT*ROUT+WOUT*QOUT)/386.4
      ETAL=(VDTOUT+ROUT*UOUT-WOUT*POUT)/386.4
      BTV=ATAN(VOUT/UOUT)
      BTVDT=(UOUT*VDTOUT-VOUT*UDTOUT)/(UOUT*UOUT)
      ONER=(ROUT+BTVDT)/SQRT(UOUT**2+VOUT**2)
C     COMPARISON VARIABLE DATA COLLECTION
      IF(IVHTP.GT.2) GO TO 402
C     COMPARISON VARIABLES FOR VHTP # 1
C     AXAVE = AVERAGE LONGITUDINAL DECELERATION
      IF(U.GT.(UIN-88.)) GO TO 400
      AXI = AXI + ETAX
      GO TO 401
  400 TIMIN5 = TIME
  401 CONTINUE
      TIMDEC  = TIME - TIMIN5
  402 CONTINUE
      IF(IVHTP.NE.2) GO TO 412
C     VHTP #2 COMPARISON VARIABLES
C     AVERAGE PATH CURVATURE RATIO , CUVRAT
C     AVERAGE LONGITUDINAL DECELERATION, AXAVE
```

```
C     PEAK BODY SIDESLIP RATE, BETDMX
      IF (TIME.LT.CGAM) GO TO 410
      IF( TIME.GT.(CGAM + 1.)) GO TO 411
      CURVAV = CURVAV + ONER
      ABBTV = ABS(BTV)
      ABTVDT = ABS(BTVDT)
      IF(ABBTV.GT.BETAMX) BETAMX = ABBTV
      IF(ABTVDT.GT.BETDMX) BETDMX = ABTVDT
      GO TO 411
 410  CURTPP = ONER
 411  CONTINUE
  412 CONTINUE
      IF(IVHTP.NE.3) GO TO 422
C     VHTP #3
      IF((GETDL.LE.0.).AND.(JUMP.EQ.0)) GO TO 420
      IF(TIME.GT.(TIMBMP + 1))  GO TO 421
      JUMP =1
      CURVAV = CURVAV + ONER
      ABTVDT = ABS(BTVDT)
      ABBTV  = ABS(BTV)
      IF(ABTVDT.GT.BETDMX) BETDMX = ABTVDT
      IF(ABBTV.GT.BETAMX) BETAMX = ABBTV
      GO TO 421
  420 CURTBP = ONER
      TIMBMP =  TIME
  421 CONTINUE
  422 CONTINUE
      IF(IVHTP.NE.4) GO TO 432
C     VHTP #4  COMPARISON VARIABLES
      IF(TIME.LT.TST) GO TO 430
      IF(TIME.GT.(TST + 2.)) GO TO 431
      CURVAV = CURVAV + ONER
      ABTVDT = ABS(BTVDT)
      ABBTV  = ABS(BTV)
      IF(ABTVDT.GT.BETDMX) BETDMX = ABTVDT
      IF(ABBTV.GT.BETAMX) BETAMX = ABBTV
      DELBET = BETAMX - BETA
      GO TO 431
 430  BETA = BTV
 431  CONTINUE
  432 CONTINUE
      IF(IVHTP.NE.5) GO TO 442
C     VHTP #5  COMPARISON VARIABLES
      IF(TIME.GT.((1./FREQ) + 1.4)) GO TO 450
      IF(DSW.GT.0) GO TO 460
      DELSTR= DELSTR + ABS(Y + 144.)
      GO TO 461
  460 CONTINUE
      DELSTR=DELSTR + ABS(Y - 144.)
  461 CONTINUE
      ABBTV = ABS(BTV)
      IF(ABBTV.GT.BETAMX) BETAMX = ABBTV
      DELPSI = PSI
  450 CONTINUE
  442 CONTINUE
C     VHTP #6 COMPARISON VARIABLE
      IF(ABS(PHIDT).GT.PHIDMX) PHIDMX = ABS(PHIDT)
      IF(ABS(ETAL).GT.AYMAX) AYMAX= ABS(ETAL)
      TEMPE=ABS(ROUT/RAD)
      IF(TEMPE.GT.RMAX)RMAX=TEMPE
```

```
      TEMPE=ABS(PSIOUT)
      IF(TEMPE.GT.PSIMAX)PSIMAX=TEMPE
      TEMPE=ABS(PHIOUT/RAD)
      IF(TEMPE.GT.PHIMAX)PHIMAX=TEMPE
      IF(UOUT.GE.10.0*MPHIPS)TIME10=TIME
      IF(UOUT.GE.25.0*MPHIPS)TIME25=TIME
      IF(TIME.LE.5.0)PSI5=PSIOUT/RAD
      RETURN
      END
```

2.1.15 RTMON

PRESENTED HERE IS THE FORTRAN LISTING FOR THE REAL-TIME MODE INITIALIZATION SUBPROGRAM. THE FOLLOWING IS PERFORMED IN RTMON:

1) Initialization of order programs to perform real-time input/output.
2) Initiation of simulation runs.
3) Suspension of the simulation's OS processing until the real-time processing is completed.

```
C     SUBROUTINE RTMON
      SUBROUTINE RTMON
C***********************************************************************
C     THIS SUBPROGRAM PERFORMS THE FOLLOWING:
C        1) INITIALIZATICN OF ORDER PROGRAMS TO PERFORM REAL-TIME
C           INPUT/OUTPUT
C        2) INITIATION OF SIMUIATION RUNS
C        3) SUSPENSION OF THE SIMULATION'S OS PROCESSING UNTIL THE
C           REAL-TIME PROCESSING IS COMPLETED
C***********************************************************************
      COMMON/OSMON/ IREALT,NNNN
      COMMON/APL/ OPEN  ,RTSW  ,LDTSW ,RBSW
      COMMON/RBBLK/ AD1RB,ICRB,OPRB,PILRB
      COMMON /RBBLK/ TCNBUF,TIMBUF,LDARB ,TDARB ,PILRB1
      COMMON/RBBLK/SLRB05,RLRB05
      COMMON /ECBBLK/PILECB,TCNECB,TIMECB,ADAECB,TDAECB
      COMMON/ECBBLK/ AD1ECB,ICECB,OPECB
      COMMON /ECBBLK/OSECB ,DONECB,SLECB5,RLECB5
      COMMON/INOUT/ IN(32),DACO(48),ISW1,ISW7,IPRT
C
      REAL*8                   PILRB(3)   ,LDARB(23)   ,TCNBUF(8)
      REAL*8       IIMBUF(8)
      REAL*8       SAVE2(16)  ,PILRB1(3)               ,AD1RB(12)
      REAL*8                   OPRB(6)    ,TDARB(6)
      REAL*8       SAVE0(16)  ,SAVE1(16)               ,ICRB(6)
      REAL*8   SLRB05(6),RLRB05(6)
C
      REAL*4              IN
      REAL*4       ADC2(24)   ,ADC1(24)
C
      INTEGER*4                TCNECB     ,TIMECB
      INTEGER*4    CONSL/01/  ,PILECB     ,ADAECB      ,TDAECB
      INTEGER*4                           IMODOP/04/  ,OPECB
      INTEGER*4 FIRST/0/,LAST/47/
      INTEGER*4 NONE/0/,AD1ECB, IMODIC/06/,ICECB
      INTEGER*4      MONE/-1/   ,F1/00/     ,L1/27/
      INTEGER*4    TDAECB
      INTEGER*4    OSECB       ,DONECB
      INTEGER*4   SCL05/5/,RCL05/5/,SLECB5,RLECB5
C
      INTEGER*2                NUMEVT/03/ ,ZERO/00/
      INTEGER*2    UNIT/19/
      INTEGER*2 TWO/02/
      INTEGER*2    RTSW  ,RBSW   ,LDTSW ,OPEN  ,OPDN
C
      EQUIVALENCE (ADC1(24),IN(24))     ,(ADC2(1),IN(25))
C
      EXTERNAL        INIT,CART ,ENDRUN,HYBINT
C
      IF( RBSW.EQ.1 ) GO TO 200
         CALL BLJCB( 'J007',OSECB,NUMEVT,NONE )
         CALL DEFEP( INIT,SAVE0,ZERO,'NONE','NO' )
         CALL DEFEP( ENDRUN,SAVE1,ZERO,'NONE','NO' )
         CALL DEFEP( CART,SAVE2,ZERO,'NONE','NO' )
         CALL CRBCRB( F1,L1,ADC1,AD1RB,AD1ECB,CONSL )
         CALL TLDARB( TDARB,TDAECB,CONSL )
         CALL SSCLRB(SCL05,SLRB05,SLECB5,CONSL)
         CALL RSCLRB(RCL05,RLRB05,RLECB5,CONSL)
         CALL SAMORB( IMODIC,ICRB,ICECB,CONSL )
```

```
         CALL SAMORB( IMODOP,OPRB,OPECB,CONSL )
         OPDN    = 0
         RBSW    = 1
  200 CONTINUE
      IF(IREALT.EQ.0 ) GO TO 210
      IF( OPDN.EQ.1 )  GO TO 205
         OPDN    = 1
         CALL RTOPN
         CALL RTACT( ZERO,'J007' )
  205 CONTINUE
         CALL DEFPR( UNIT,HYBINT,'J007' )
         LDTSW   = 0
         OSECB   = 0
         CALL RTACT( TWO ,'J007' )
         CALL WAITRT( OSECB )
         CALL WAITBU( 200 )
         CALL DEFPR( UNIT,MONE,'J007' )
      GO TO 215
  210 CONTINUE
         CALL LBDAFP( FIRST,LAST,DACO,IERR )
         CALL TLDA
         CALL CRBCFP( F1,L1,ADC1,ICRBCE )
      CALL MODEL
  215 CONTINUE
      RETURN
      END
```

2.1.16 RTIME

PRESENTED HERE IS THE FORTRAN LISTING OF THE REAL-TIME EXECUTIVE SUBPROGRAM. THE FOLLOWING IS PERFORMED IN RTIME:

1) Assignment of priority interrupt addresses to real-time events.
2) Initiation of the interval timer for computation cycle timing.
3) Execution of all real-time input/output.
4) Checks for end-of-run conditions.
5) Deactivation of real-time mode at the end of a simulation run.

```
C     SUBROUTINE RTIME
      SUBROUTINE RTIME
C***********************************************************************
C     THIS SUBPROGRAM PERFORMS THE FOLLOWING:
C        1) ASSIGNMENT OF PRIORITY INTERRUPT ADDRESSES TO
C           REAL-TIME EVENTS
C        2) INITIATION OF THE INTERVAL TIMER FOR COMPUTATION CYCLE
C           TIMING
C        3) EXECUTION OF ALL REAL-TIME INPUT/OUTPUT
C        4) CHECKS FOR END-OF RUN CONDITIONS
C        5) DEACTIVATION OF REAL-TIME MODE AT THE END OF A
C           SIMULATION RUN
C***********************************************************************
      COMMON/APL/ OPEN  ,RTSW  ,LDTSW ,RBSW
      COMMON/RBBLK/ AD1RB,ICRB,OPRB,PILRB
      COMMON /RBBLK/ TCNBUF,TIMBUF,LDARB ,TDARB ,PILRB1
      COMMON/RBBLK/SLRB05,RLRB05
      COMMON /ECBBLK/PILECB,TCNECB,TIMECB,ADAECB,TDAECB
      COMMON/ECBBLK/ AD1ECB,ICECB,OPECB
      COMMON /ECBBLK/OSECB ,DONECB,SLECB5,RLECB5
      COMMON/INOUT/ IN(32),DACO(48),ISW1,ISW7,IPRT
      COMMON/VARS/P,Q,R,U,V,W,X,Y,Z,THE,PHI,PSI,PO,QO,RO,UO,VO,WO,XO,
     1 YO,ZO,THEO,PHIC,PSIO
      COMMON/TIMBLK/JJTIME,TIME,DT
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      COMMON/NEWER/TIME25,TIME10,PSI5,PHIMAX,DSWMAX
      COMMON/NONAME/XEND,O,EXIT2
      COMMON/NODLY/INDXCN
      DIMENSION CSI(4),XBM(4),SLP(4)
      REAL*8       BUFF(8)    ,PILRB(3)    ,LDARB(23)   ,TCNBUF(8)
      REAL*8       TIMBUF(8)
      REAL*8 ICRB(6),PILRB1(3), AD1RB(12)
      REAL*8                   OPRB(6)     ,TDARB(6)
      REAL*8     BUFF1(8)
      REAL*8  SLRB05(6),RLRB05(6)
C
      REAL*4               IN
      REAL*4       ADC2(04)    ,ADC1(24)
C
      INTEGER*4   TIMCAN      ,TCNECB      ,TIMECB
      INTEGER*4   CONSL/01/   ,PILECB      ,ADAECB      ,TDAECB
      INTEGER*4               EVTRET/02/ ,TIMINT/120000/
      INTEGER*4 SLECB5,RLECB5 ,            FIRST/00/   ,LAST/47/
      INTEGER*4 OPECB,AD1ECB,ICECB
      INTEGER*4   TDAECB      ,STATUS
      INTEGER*4   OSECB       ,DONECB
      INTEGER*4  PILCB1
C
      INTEGER*2   PILIST(2)/1,0/,EVTLST/1/
      INTEGER*2   TWO  /02/ ,ONE/01/
      INTEGER*2   RTSW  ,RBSW  ,LDTSW ,OPEN
C
      EQUIVALENCE (ADC1(24),IN(24))     ,(ADC2(1),IN(25))
C
C     EVENT 0
C
      ENTRY INIT
         CALL PGET( PILIST, 0  ,'J007',PILRB1 )
         PILECB = 0
```

```
         CALL PCAN( PILIST,BUFF,PILECB )
         CALL HIOCHK( PILECB )
         CALL PEVT( PILIST,EVTLST,'J007',PILRB )
         DONECB = 0
         CALL HWAIT( DONECB )
         CALL PREL( PILIST,'J007',PILRB1 )
         CALL HDONE( 'DN' )
      CALL HEXIT
C
C     EVENT 1
C
      ENTRY ENDRUN
      TCNECB = 0
         CALL RDTIMR( TIMCAN,TCNECB,'CANC',TCNBUF )
         CALL HIOCHK( TCNECB )
         PILECB = 0
         CALL PDAC( PILIST,BUFF,PILECB )
         CALL HIOCHK( PILECB )
         PILECB = 0
         CALL PCAN( PILIST,BUFF,PILECB )
         CALL HIOCHK( PILECB )
      ICECB  = 0
         CALL HIOREQ( ICRB )
         CALL HIOCHK( ICECB )
         CALL RTCAN( TWO   ,STATUS )
         CALL HOSPST( 'FN' )
      CALL HEXIT
C
C     EVENT 2
C
      ENTRY CART
      IF( LDTSW.EQ.1 ) GO TO 230
      PILCB1 = 0
         CALL PACT( PILIST,BUFF1,PILCB1 )
         CALL HIOCHK ( PILCB1 )
      TIMECB = 0
      TIMINT = 1.E06*DT/PARAM(175)
         CALL LDTIMR( TIMINT,TIMECB,EVTRET,TIMBUF )
      OPECB  = 0
         CALL HIOREQ( OPRB )
         LDTSW  = 1
      GO TO 250
  230 CONTINUE
      SLECB5=0
      TDAECB = 0
      AD1ECB = 0
         CALL HIOREQ(SLRE05)
         CALL HIOREQ( AD1RB )
      J=0
      DO 200 I=1,INDXCN
      J=J+1
200   CONTINUE
         CALL HIOCHK( AD1ECB )
      CALL MODEL
      ADAECB = 0
      RLECB5=0
         CALL LBDART( FIRST,LAST,DACO,LDARB ,ADAECB,CONSL )
         CALL HIOREQ( TDARB )
         CALL HIOREQ(RLRB05)
C     APL WILL TERMINATE REAL-TIME RUN IF EITHER
```

```
C     CONDITION SHOWN BELOW IS SATISFIED
      C=SQRT(U*U+V*V)
      IF(U.LE.0.1)CALL RTACT(ONE,'J007')
      IF(PHIMAX.GT.15.) CALL RTACT(ONE,'J007')
      IF(( ISW1.EQ.1 ).OR.( ISW7.EQ.1 )) CALL RTACT( ONE    ,'J007' )
      IF( TIME.LE.XEND.AND.O.GE.EXIT2 ) GO TO 250
      CALL RTACT( ONE,'J007' )
  250 CONTINUE
      CALL HEXIT
      RETURN
      END
```

2.1.17 CMPVAR

PRESENTED HERE IS THE FORTRAN LISTING FOR THE PERFORMANCE COMPARISON VARIABLE (PCV) CALCULATION SUBPROGRAM. THE CALCULATION AND OUTPUT OF THE PCV'S ARE PERFORMED IN CMPVAR FOLLOWING EACH SIMULATION RUN.

```
C     SUBROUTINE CMPVAR
      SUBROUTINE CMPVAR
C***********************************************************************
C     THE CALCULATION AND OUTPUT OF THE CV'S ARE PERFORMED IN THIS
C     SUBPROGRAM FOLLOWING EACH SIMULATICN RUN
C***********************************************************************
      COMMON/COMVAR/ AXAVE,CUVRAT,BETDMX,CURTBP,TIMDEC,JUMP,DELSTR,DEL,
     1              AXI,CURVAV,ABBTV,AYMAX,RMAX,DELBET,DELPSI,BETAMX,
     1              TIMEMP,GETDL,TIMIN5,       DT,       IVHTP
      COMMON/THINGS/TMAX1,TMAX2,TMAX3,TQRMAX,TQFMAX,PSIMAX,ONER
      COMMON/NEWER/TIME25,TIME10,PSI5,PHIMAX,DSWMAX
      DATA CURV1G/.00078/
      DATA LPTR/2/
C     CALCULATION OF COMPARISON VARIABLES
      IF(TIMDEC.EQ.0.) TIMDEC=.000000001
      IF(CURTBP.EQ.0. ) CURTBP=.00000001
      GO TO(1,2,3,4,5,6) , IVHTP
      AXAVE = AXI*DT/TIMDEC
      GO TO 10
    1 CONTINUE
      AXAVE = AXI*DT/TIMDEC
      GO TO 10
    2 CONTINUE
      AXAVE = AXI*DT/TIMDEC
      CUVRAT =  CURVAV * DT/CURTBP
      GO TO 10
    3 CONTINUE
      CUVRAT = CURVAV * DT/CURTBP
      GO TO 10
    4 CONTINUE
      CUVRAT = CURVAV*.5*DT/CURV1G
      GO TO 10
    5 CONTINUE
      DEL= (DELSTR*DT/3.4)/12.
    6 CONTINUE
   10 CONTINUE
      RMAX = RMAX/57.3
      WRITE(LPTR,2345) AXAVE,TIMDEC,CUVRAT,BETDMX,BETAMX,DELBET,
     1AYMAX,PHIMAX,RMAX,DEL,DELPSI,DSWMAX,TQFMAX,TQRMAX
 2345 FORMAT('0 AXAV=',F8.3,' DECL TIME=',F8.3,' AVCUR=',F8.3,' BTDMAX='
     1,F8.3,' BTMAX=',F8.3,' DELBT=',F8.3/
     1'0AYMAX=',F8.3,' PHIMAX=',F8.3,' RMAX=',F8.3,' LANE CHNG DEL=',
     1F8.3,' DELPSI=',F8.3,' MAX STEER=',F8.3/
     1'0FTRQMAX=',F9.3,' RTRQMAX=',F9.3/)
      RETURN
      END
```

2.1.18 QSTD

PRESENTED HERE IS THE FORTRAN LISTING OF THE SUBPROGRAM WHICH OUTPUT NON-STANDARD DATA. THE PERFORMANCE COMPARISON VARIABLES ARE OUTPUT FROM QSTD.

```
C     SUBROUTINE QSTD
      SUBROUTINE QSTD
C*************************************************************************
C     STANDARD END OF RUN DATA IS OUTPUT FROM THIS SUBPROGRAM
C*************************************************************************
      COMMON/DEVICE/KEYBD,ITTY,ICDRD,LPTR,LPNT
      COMMON/COMVAR/ AXAVE,CUVRAT,BETDMX,CURTBP,TIMDEC,JUMP,DELSTR,DEL,
     1               AXI,CURVAV,ABBTV,AYMAX,RMAX,DELBET,DELPSI,BETAMX,
     1               TIMBMP,GETDL,TIMIN5,        TSTEP ,   IVHTP
      COMMON/THINGS/TMAX1,TMAX2,TMAX3,TQRMAX,TQFMAX,PSIMAX,ONER
      COMMON/NEWER/TIME25,TIME10,PSI5,PHIMAX,DSWMAX
      WRITE(ITTY,2345) AXAVE,TIMDEC,CUVRAT,BETDMX,BETAMX,DELBET,
     1AYMAX,PHIMAX,RMAX,DEL,DELPSI,DSWMAX,TQFMAX,TQRMAX
 2345 FORMAT('0 AXAV=',F8.3,' DECI TIME=',F8.3,' AVCUR=',F8.3,' BTDMAX='
     1,F8.3,' BTMAX=',F8.3,' DELBT=',F8.3/
     1' AYMAX=',F8.3,' PHIMAX=',F8.3,' RMAX=',F8.3,' LANE CHNG DEL=',
     1F8.3,' DELPSI=',F8.3,' MAX STEER=',F8.3/
     1' FTRQMAX=',F10.0,' RTRQMAX=',F10.0/)
      RETURN
      END
```

2.1.19 ERMONT

PRESENTED HERE IS THE FORTRAN LISTING FOR THE ABNORMAL SIMULATION OPERATION SUBPROGRAM. THE CONDITIONS OF VEHICLE ROLL-OVER, DIGITAL-TO-ANALOG CONVERTER OVERRANGE, AND ANALOG-TO-DIGITAL CONVERTER OVERRANGE ARE DETECTED BY ERMONT WHEN SINGLE RUN EXECUTION IS PERFORMED.

```
C     SUBROUTINE ERMONT(MOPU,ORNAME,PHIMAX)
      SUBROUTINE ERMONT(MOPU,ORNAME,PHIMAX)
C*********************************************************************
C     THE CONDITIONS OF VEHICLE RCLL-OVER, DIGITAL-TO-ANALOG CONVERTER
C     CVERRANGE, ANC ANALCG-TO-DIGITAL OVERRANGE  ARE DETECTED BY
C     THIS SUBPROGRAM WHEN SINGLE RUN EXECUTION IS PERFORMED
C*********************************************************************
      COMMON/EMON/IERDAC(10),TERDAC(10),IDACK,IENDR(20)
      COMMON/ERMON2/ IERADC(10),TERADC(10),IADCK
      COMMON/DACADC/ NAMEAC,NAMADC,IDAC,IADC,ADCNUM,DACNUM
      INTEGER*2 NAMDAC(48),NAMADC(48),IDAC(48),IADC(48),ADCNUM,DACNUM
      REAL*8 CRNAME(400)
      IF(PHIMAX.LT.15.) GO TO 200
      WRITE(MOPU,205) PHIMAX
  205 FORMAT(' VEHICLE RCLL OVER PHIMAX=',F8.2)
  200 CONTINUE
      IF(IDACK.LT.1) GO TO 100
      WRITE(MOPU,105)
      WRITE(MOPU,106)
      WRITE(MOPU,107)  (TERDAC(J),CRNAME(NAMDAC(IERDAC(J))),
     1 IDAC(IERDAC(J)),J=1,IDACK)
  105 FORMAT(' DAC OVERLOAD')
  106 FORMAT('  TIME        VAR')
  107 FORMAT(F8.2,2X,A6,'(',I4,')')
  100 CONTINUE
      IF(IADCK.LT.1) GO TO 300
      WRITE(MOPU,305)
      WRITE(MOPU,106)
      WRITE(MOPU,107)  (TERADC(J),CRNAME(NAMADC(IERADC(J))),
     1 IADC(IERADC(J)),J=1,IADCK)
  305 FORMAT(' ADC OVER RANGE')
  300 CONTINUE
      RETURN
      END
```

2.1.20 NTRACT

PRESENTED HERE IS THE FORTRAN LISTING FOR THE NTRACT SUBPROGRAM. THIS SUBPROGRAM IS FOR SIMULATION CONTROL VIA THE INTERACTIVE ROUTINES USING THE OPTION COMMAND.

```
C     SUBROUTINE NTRACT(*,*,*,*)
      SUBROUTINE NTRACT(*,*,*,*)
C**********************************************************************
C     THIS SUBPROGRAM IS FOR SIMULATION CONTROL VIA THE INTERACTIVE
C     ROUTINES USING THE OPTION CCMMAND
C**********************************************************************
C
C**************************** COMMON AREAS *****************************
C
      COMMON/START/ ZDUMMY(4)
      COMMON/TABBS/ ITABP,ITABI,ITNAM,TABNUM
      COMMON/EMON/IERDAC(10),TERDAC(10),IDACK,IENDR(20)
      COMMON/ERMON2/ IERADC(10),TERADC(10),IADCK
      COMMON/NEWER/TIME25,TIME10,PSI5,PHIMAX,DSWMAX
      COMMON/DEVICE/KEYBD,ITTY,ICDRD,IPTR,LPNT
      COMMON /ECBBLK/PILECB,TCNECB,TIMECB,ADAECB,TDAECB
      COMMON/ECBBLK/ AD1ECB,ICECB,CPECB
      COMMON /ECBBLK/OSECB ,DONECB,SLECB5,RLECB5
      COMMON/OSMON/ IREALT,NNNN
      COMMON/OSTRAN/ ICT,IRT,MOPU,IRUNS,IRUNS,REALT,ITRUNS
      COMMON/DACADC/ NAMDAC,NAMADC,IDAC,IADC,ADCNUM,DACNUM
      COMMON/IO/ DACPLA,ADCPLA,SCAIDC,SCALAC
      COMMON/TRACK/JIN,IKEEP,ATRACK,ISAMP,ONTIM,OFFTIM,ITRA,
     1 ITRAA,ITRNA,ITRIA
      COMMON/UNREAD/NAMEA,IWRDCT,INUMCT,LSTART,INDEXA,
     1 FNUMA,LAST,ILOP
      COMMON/FIND/CRNAME(400),NCOM,RSVAL(002),IORDER(400)
      COMMON/TIMBLK/JJTIME,TIME,DT
      COMMON/SP7BLK/N1,N2,IPOT(120),IPOTAD(120),PARAM(400)
      COMMON/OVRLAY/ OPTEST,VALMR,FINLMR,NTIME1,NTIME2,LOCAT,LOOPN
C
C**********************************************************************
C
      REAL*8 NAMEA(10),RETURN
      REAL*8 OPTION(20),CPTEST       ,ASELT(15),REMOVE,RESET
      REAL*8 BLANK
      REAL*8 NMES,NTESTP,NTESTO
      REAL*8 NADCL,NDACL,NDUMP,NNPC,NPLOT,NSTD
      REAL*8 NTRACK,NTM,NTIMD,NTABLE
      REAL*8 CUTNAM(21),NX      ,NTERM,NRESR,NIC,NADCA
      REAL*8 NXM,UNNAM(3),MODENA(4)
      REAL*8 ORNAME
      REAL*8 NSAMPL,NLA
      REAL*8 NDACA,NMULT,CNAME,NII,NFF
      REAL*8 NUOPT,NUOT1,NSTAT
      REAL*8 ENDDAC,ENDADC
      REAL*4 ZDUMMY
      REAL*4 VALMR(20),FINLMR(20)
      REAL*4 FNUMA(10)
      REAL*4                  SCALAC(48),SCAIDC(48)
      REAL*4 IPOT,IPOTAD
      INTEGER*4 RTSW,           INDEXA(10)
      INTEGER*4 ITABI(9)
      INTEGER*4 DONECB,OSECB,TIMINT
      INTEGER*4 ITABP(9),TABNUM,ITNAM(9)
      INTEGER*2 ITRAA(50),ITRNA(50),ITRIA(50)
        INTEGER*2 LOCAT(20),LOOPN(20)
      INTEGER*2 DEVICE(21),IORDER,IMODE(20)
      INTEGER*2 DACNUM,ADCNUM,DACPLA(48),ADCPLA(48)
```

```
      INTEGER*2 NAMDAC(48),NAMADC(48),IDAC(48),IADC(48)
      DIMENSION  JDATE(3)
      DIMENSION ATRACK(2000)
      DIMENSION BVALUE(2)
      DIMENSION IVALUE(2)
      EQUIVALENCE (BVALUE(1),ZDUMMY(1))
      EQUIVALENCE (BVALUE(1),IVALUE(1))
      EQUIVALENCE (OPTION(1),NX)   ,(OPTION(2),NIC)   ,(OPTION(3),NTERM),
     1     (OPTION( 4),NADCA)  ,(OPTION( 5),NDACA)  ,(OPTION( 6),NFF)    ,
     2     (OPTION( 7),NII)    ,(OPTION( 8),NMES)   ,(OPTION( 9),NTESTP),
     3     (OPTION(10),NRESR)  ,(OPTION(11),RESET)  ,(OPTION(12),REMOVE),
     4     (OPTION(13),NMULT)  ,(OPTION(14),NXM)    ,(OPTION(15),NUOPT)
      EQUIVALENCE (ASELT( 1),NTIMD),(ASELT( 2),NDUMP),(ASELT( 3),NSTD),
     1     (ASELT( 4),NTESTO)  ,(ASELT( 5),NLA)     ,(ASELT( 6),NTRACK) ,
     2     (ASELT( 7),NTABLE)  ,(ASELT( 8),NPLOT)   ,(ASELT( 9),NDACL)  ,
     3     (ASELT(10),NADCL)   ,(ASELT(11),NSAMPL)  ,(ASELT(12),NNPC)   ,
     4     (ASELT(13),NTM)     ,(ASELT(14),NSTAT)   ,(ASELT(15),NUOT1)
C
C ******************************************************************
C
      DATA BLANK/' '/
      DATA OUTNAM/'STD','TM','TABLE',17*' '/
      DATA DEVICE/2,2,3,17*0/
      DATA IMODE/1,1,3,17*0/
      DATA UNNAM/'L.......','T.......','B.......'/
      DATA MODENA/'S.......','XEQ.....','M.......','A.......'/
C
      DATA OPTION/'X','IC', 'TERM','ADCA','DACA','F','I','MES',
     1          'TEST','RE-STR','RESET','REMOVE','MULTI','XM',
     2          'UOPT',5*'ZZZZZZZZ'/
      DATA RETURN/'        '/
      DATA ASELT/'T+D','DUMP','STD','TESTO','LA','TRACK','TABLE','PLOT',
     1          'DACL','ADCL','SAMPLE','PC','TM','STAT' ,'UOUT1'/
C        1 LOAD JDATE ARRAY
C        2 WRITE  TIME AND DATE
      CALL  IDATE(JDATE)
      CALL TIMDAT(JDATE,ITTY)
C
C*******************************************************************
C
C **************
C *            *
C * OPTION TEST * - ENTER A NAME FROM KEYBD (OPTEST)
C *            *
C **************
C
C        1 IF OPTEST IS AN OPTION KEYWORD PASS CONTROL TO OPTION EXECUTI
C        2 IF OPTEST IS AN OUTPUT KEYWORD PASS CONTROL TO OUTPUT ARRAY A
C        3 IF OPTEST IS IN THE ANAME ARRAY WRITE ITS PRESENT AND INITIAL
C        4 IF OPTEST IS EQUAL TO RESET  GO TO RESET ROUTINE
C        5 IF NONE OF THE ABOVE ENVOKE ERROR MONITOR
C
 8749 WRITE(ITTY,8754)
 8754 FORMAT(1H0,'OPTION')
      READ(KEYBD,1031) OPTEST
 1031 FORMAT(1A8)
 8450 CONTINUE
      LSTART=1
      LAST=80
C
```

```
      DO 8756 IOR=1,20
      IF(OPTION(IOR).EQ.OPTEST) GO TO 8758
 8756 CONTINUE
C
      DO 8765 IS=1,15
      IF(OPTEST.EQ.ASELT(IS)) GO TO 720
 8765 CONTINUE
C
      WRITE(ITTY,1000)
1000  FORMAT(1H0,' ERROR - OPTION NOT FOUND - RENTER ')
      GO TO 8749
C
C**********************************************************************
C
C ********************
C *                  *
C * OPTION EXECUTIVE * - CONTROL IS PASSED FROM OPTION TEST
C *                  *
C ********************
 8758 CONTINUE
C      IF OPTEST IS EQUAL TO:
C         1 X - TRANSFER CONTROL TC EXECUTION REGION
C         2 IC - TRANSFER CONTROL TO EXECUTION REGION
C         3 OUTPUT - TRANSFER CONTROL TO OUTPUT ARRAY ASSEMBLER
C              A) TABLE (SETUP END-OF-RUN OUTPUT)
C              B) TRACK (SETUP DURING RUN DATA COLLECTION)
C              C) LA (LIST ARRAY VALUES)
C              D) T+D (OUTPUT TIME AND DATE)
C              E) STD (STANDARD OUTPUT)
C              F) DUMP (OUTPUT ALL VARIABLES)
C              G) SAMPLE (SETUP FOR REAL-TIME DATA COLLECTION)
C         4 TERM - TRANSFER CONTROL TO TERMINAL REGION
C         5 ADCA - ALTER ADC ARRAY
C         6 DACA - ALTER DAC ARRAY
C         7 F - FLOATING POINT OPERATIONS
C         8 I - INTEGER OPERATIONS
C         9 MES - SEND MESSAGE TO LINE PRINTER
C        10 TEST - EXECUTE TEST ROUTINE
C        11 RE-STR - RESTARTS (READS IN NEW DATA)
C        12 RESET - LOADS OUTPUT NAME ARRAY WITH BLANKS
C        13 REMOVE - REMOVES NAMES FROM OPTION LIST
C        14 MULTI - SETS UP MULTI RUN LOOP & VARIABLES
C        15 XM - TRANFER CONTROL TO EXECUTION REGION FOR MULTI RUNS
C        16 UOPTION - USER OWN OPTION SUBROUTINE
C
      IF(OPTEST.EQ.NX) GO TO 8802
      IF(OPTEST.EQ.NIC) GO TO 8802
      IF(OPTEST.EQ.NXM) GO TO 8802
      IF(OPTEST.EQ.NTERM) GO TO 8809
      IF(OPTEST.EQ.RESET) GO TO 8230
      IF(OPTEST.EQ.REMOVE) GO TO 8234
      IF(OPTEST.EQ.NRESR) RETURN 1
C
C *********************************************************************
C
      IF(OPTEST.NE.NADCA) GO TO 5000
C ##### --- ADC ROUTINE ---#####
      CALL ADCA(ADCNUM,NAMADC,IADC,SCALAC,ADCPLA,ITTY,KEYBD)
 5000 CONTINUE
      IF(OPTEST.NE.NII.AND.OPTEST.NE.NFF) GO TO 5010
```

```
C #####---ALTER OR READ DATA LIST ---#####
      CALL RDWRT(OPTEST)
 5010 CONTINUE
      IF(OPTEST.NE.NDACA) GO TO 5020
C #####---DAC ROUTINE ---#####
      CALL DACA (DACNUM,NAMDAC,IDAC,SCALDC,DACPLA,ITTY,KEYBD)
 5020 CONTINUE
      IF(OPTEST.NE.NMES) GO TO 5035
C #####--- MESSAGE ROUTINE ---#####
      CALL MESRTN(ITTY,KEYBD,RETURN,LPTR)
 5035 CONTINUE
      IF(OPTEST.NE.NMULT) GO TO 5040
C #####--- MULTI RUN ---#####
      CALL MULTRN (ITTY,LOCAT,LOOPN,VALMR,FINLMR,ICT,IRUNS)
 5040 CONTINUE
      IF(OPTEST.NE.NTESTP) GO TO 5050
C #####--- TEST OPTION ---#####
      CALL TESTP(KEYBD,ITTY,NCOM,CRNAME,IORDER,BVALUE,RSVAL,REALT)
 5050 CONTINUE
      IF(OPTEST.NE.NUOPT) GO TO 5070
C #####--- USER OPTION SUBROUTINE ---#####
      WRITE(ITTY,8764)
5070  CONTINUE
      GO TO 8749
C
C*********************************************************************
C
C ***************************
C *                         *
C * OUTPUT ARRAY ASSEMBLER * - CALLED FROM THE OPTION TEST OR EXECUTIVE
C *                         *
C ***************************
C
  720 WRITE(ITTY,700)
  700 FORMAT(1H ,'UNIT,MODE')
      CALL UNFORM(5,1)
      DO 705 IOU=1,3
      IF(UNNAM(IOU).EQ.NAMEA(1)) GO TO 710
  705 CONTINUE
      WRITE(ITTY,715)
  715 FORMAT(1H ,'FOR UNIT ENTER  L (LIN PT), T (TELE), B (BOTH)')
      GO TO 720
  710 DO 725 MODE=1,4
      IF(MODENA(MODE).EQ.NAMEA(2)) GO TO 730
  725 CONTINUE
      WRITE(ITTY,735)
  735 FORMAT(1H ,'FOR MODE ENTER A (ALL), S (SING.), M (MULTI),
     1 XEQ (EXECUTION)')
      GO TO 720
  730 CONTINUE
C
      IF(OPTEST.NE.NLA) GO TO 2005
C #####--- ARRAY SET UP ---####
      CALL ARAST
 2005 CONTINUE
      IF(OPTEST.NE.NTABLE) GO TO 2010
C #####--- TABLE SET UP ---#####
      CALL TABLES(ITTY,KEYBD)
 2010 CONTINUE
      IF(OPTEST.NE.NTRACK) GO TO 2020
```

```
C #####--- TRACK ROUTINE ---#####
      CALL TRACKS(ITTY,KEYBD,DT)
 2020 CONTINUE
      IF(OPTEST.NE.NSAMPI) GO TO 2030
C #####--- REAL TIME SAMPLE SETUP SUBROUTINE ---#####
      WRITE(ITTY,8764)
 2030 CONTINUE
C #####--- SET UP OUTPUT NAME ARRAY ---#####
      IF(MODE.NE.2) GO TO 670
      OUTNAM(21)=OPTEST
      DEVICE(21)=IOU
      GO TO 8253
  670 DO 741 JJ=1,20
      IF(OUTNAM(JJ).EQ.OPTEST) GO TO 740
  741 CONTINUE
      DO 745 JJ=1,20
      IF(OUTNAM(JJ).EQ.BLANK) GO TO 740
  745 CONTINUE
  740 OUTNAM(JJ)=OPTEST
      IMODE(JJ)=MODE
      DEVICE(JJ)=ICU
      GO TO 8749
C #####--- REMOVE SINGLE VARIABLE ---#####
 8234 CONTINUE
      WRITE(ITTY,350)
  350 FORMAT(1H ,'WHAT')
      READ(KEYBD,1031) OPTEST
      DO 7350 I=1,20
      IF(OUTNAM(I).EQ.OPTEST) OUTNAM(I)=BLANK
 7350 CONTINUE
      GO TO 8749
C #####--- RESET OUTPUT NAME ARRAY ---#####
C
C     LOAD OUTPUT NAME ARRAY WITH BLANKS
 8230 DO 8231 I=1,20
      OUTNAM(I)=BLANK
 8231 CONTINUE
      GO TO 8749
C**********************************************************************
C
C *******************
C *                 *
C * EXECUTION REGION * - CONTROL IS TRANSFERED FROM OPTION EXECUTIVE
C *                 *
C *******************
 8802 CONTINUE
C          1 FILL BVALUE ARRAY WITH INITIAL CONDITIONS
C          2 SET POTS
C          3 SET DACS
C          4 EQUIVALENCE + STORE IC
C          5 IF REAL TIME IS CALLED ENTER FLAGE
C          6 WRITE TIME,DATE, AND RUN NUMBER
C          7 CHANGE ANALOG MODE
C *********************************************************************
C
C####--- RUN COUNTER LOGIC ---#####
C
      IF(OPTEST.EQ.NIC) GO TO 170
      LRUNS=LRUNS+1
      ITRUNS=ITRUNS+1
```

```
  170 CONTINUE
C
C *                   *
C#####--- FIRST MULTI RUN VARIABLE INITIALIZATION PASS ---#####
C *                   *
C *******************
      IF(ICT.EQ.0.OR.OPTEST.NE.NXM) GO TO 165
      DO 160 I=1,ICT
      IF(LRUNS.LT.LOOPN(I)) GO TO 160
      KTEMP=IRUNS-LOOPN(I)
      BVALUE(LOCAT(I))=VALMR(I)+FLOAT(KTEMP)*FINLMR(I)
  160 CONTINUE
  165 CONTINUE
C
C #####--- USER INITIALIZATION SUBROUTINES
      RETURN 2
      ENTRY NTRAT1(*,*,*,*)
C *******************
C *                   *
C#####--- SECCND PASS FOR MULTI-RUN VARIABLE REINITIALIZATION ---#####
C *                   *
C *******************
      IF(ICT.EQ.0.CR.OPTEST.NE.NXM) GO TO 155
      DO 150 I=1,ICT
      IF(LRUNS.LT.LOOPN(I)) GO TO 150
      KTEMP=IRUNS-LOOPN(I)
      BVALUE(LOCAT(I))=VALMR(I)+FIOAT(KTEMP)*FINLMR(I)
  150 CONTINUE
  155 CONTINUE
C
C **********************************************************************
C
C     THIS ROUTINE SETS PCTS ON 680
C
      IF(REALT.LT..5) GO TO 75
      DO 1702 I=1,120
      IF(IPOT(I).EQ.IPOTAD(I)) GO TO 1702
      CALL POTCHK(I,IPOT(I),3,&8152,&8152)
      IPOTAD(I)=IPOT(I)
 1702 CONTINUE
   75 CONTINUE
C
C     THIS CALL PLACES THE 680 IN IC
C
      CALL SAMO(6,ISAMOE)
      IKEEP = ISAMP - 1
      PASS = ASAMPL
      IDACK=0
      IADCK = 0
      JIN=0
      IF(OPTEST.EQ.NIC) GO TO 8749
C
      CALL WAITBU (200)
C
      IF(LRUNS.GT.1) GO TO 1888
      CALL TIMDAT(JDATE,ITTY)
      CALL TIMDAT(JDATE,LPTR)
C
      WRITE(LPTR,9050) ITRUNS
      WRITE(ITTY,9050) ITRUNS
```

```
 9050 FORMAT(1H0,'RUN ',I3,' HAS STARTED'/1H0,
     1 'OUTPUT BELOW')
 1888 CONTINUE
C
      CALL CLOCK(NTIME1)
C
C     *****     *****     *****     *****     *****     *****     *****
C
C#####--- ENTER REAL TIME PART ---#####
C *             *
      IREALT = 0
      IF(REALT.GT..5) IREALT = 1
      IF(REALT.GT..5) IRT=1
C *             *
C    AT THIS POINT THE RTMON SUBPROGRAM IS ACTIVATED
C    RTMON INTURN EXECUTS THE MODIE
C
C-----------------------------------------------------------------------
      RETURN3
      ENTRY NTRAT2(*,*,*,*)
C-----------------------------------------------------------------------
C    WHEN EXECUTION TAKES PLACE THE FOLLOWING TAKES PLACE:
C       1 REAL TIME PRECENT IS CALCULATED
C       2 CHANGE ANALOGE MODE
C       3 CALCULATE RUN MODE
C       4 EXECUTE SELECTED OUTPUTS FOR GIVEN MODE
C              B MODE=3 FOR MULTI-RUN
C              A MODE=1 FOR SINGLE RUN
C       5 IF MODE IS EQUAL TO TWO GO TO OPTION TEST
C       6 IF PROGRAM IS IN MULTI-RUN IRUNS IS GREATOR THAN LRUNS
C              A INCREMENT VARIABLES SELECTED
C              B EXECUTE NEXT RUN
C       7 END OF RUN LRUNS=0, IRUNS=1
C       8 RETURN TO OPTION TEST
C
C ******************
C
      CALL CLOCK(NTIME2)
      NRTIME=NTIME2-NTIME1
      IF(NRTIME.GT.1) RTPER= (TIME*10000.)/FLOAT(NRTIME)
      MODE=1
      IF(OPTEST.EQ.NXM) MODE=3
 8253 CONTINUE
C ******************
C *                *
C * OUTPUT REGION  * - CONTROL IS TRANFERED FROM OPTION RUN EXECUTIVE
C *                *
C ******************
      DO 8943 I=1,20
      IFR=1
      ILA=2
      IF(MODE.NE.2) GO TO 555
      CNAME=OUTNAM(21)
      IF(DEVICE(21).EQ.1) ILA=1
      IF(DEVICE(21).EQ.2) IFR=2
      I=20
      GO TO 550
  555 IF(IMODE(I).EQ.4) GO TO 560
      IF(IMODE(I).EQ.MODE) GO TO 560
      GO TO 8943
```

```
  560 CNAME=OUTNAM(I)
      IF(CNAME.EQ.BLANK) GO TO 8943
      IF(DEVICE(I).EQ.1) ILA=1
      IF(DEVICE(I).EQ.2) IFR=2
  550 CONTINUE
      DO 8946 K=IFR,ILA
      IF(K.EQ.1) MOPU=LPTR
      IF(K.EQ.2) MOPU=ITTY
      IF(CNAME.NE.NADCL) GO TO 3000
C#####--- LIST ADC ARRAY ---#####
      CALL LSTADC(ADCNUM,MOPU,IADC,SCALAC,NAMADC,ORNAME)
      GO TO 8946
 3000 CONTINUF
      IF(CNAME.NE.NDACL) GO TO 3010
C#####--- LIST DAC ARRAY ---#####
      CALL LSTDAC(DACNUM,MOPU,IDAC,SCALDC,NAMDAC,ORNAME)
      GO TO 8946
 3010 CONTINUE
      IF(CNAME.NE.NDUMP) GO TO 3020
C#####--- DUMP ---#####
      CALL DUMP (MOPU,NCCM,IORDER,ORNAME,BVALUE)
      GO TO 8946
 3020 CONTINUE
      IF(CNAME.NE.NLA) GO TO 3030
C#####--- LIST ARRAYS & VALUES ---#####
      CALL ARAWT(MOPU,BVALUE,ORNAME)
      GO TO 8946
 3030 CONTINUE
      IF(CNAME.NE.NNPC) GO TO 3040
C#####--- SPECIAL PROGRAM END OF RUN DATA ---#####
      WRITE(ITTY,8764)
      GO TO 8946
 3040 CONTINUE
      IF(CNAME.NE.NPLOT) GO TO 3050
C#####--- PLOTING SUBROUTINE ---#####
      WRITE(ITTY,8764)
      GO TO 8946
 3050 CONTINUE
      IF(CNAME.NE.NSTAT) GO TO 3060
      WRITE(ITTY,8764)
      GO TO 8946
 3060 CONTINUE
      IF(CNAME.NE.NSTD) GO TO 3070
C#####--- STANDARD OUTPUT SUBROUTINE ---#####
      CALL QSTD(MOPU)
      GO TO 8946
 3070 CONTINUE
      IF(CNAME.NE.NTABLE) GO TO 3080
C#####--- TABLE OUTPUT ---#####
      CALL TABLEO(MOPU,ORNAME,LRUNS,ITRUNS,BVALUE)
      GO TO 8946
 3080 CONTINUE
      IF(CNAME.NE.NTESTO) GO TO 3085
C#####---TEST VALUE OUTPUT ---#####
      WRITE(ITTY,8764)
      GO TO 8946
 3085 CONTINUE
      IF(CNAME.NE.NTIMD) GO TO 3090
C#####---DATE---#####
      CALL TIMDAT(JDATE,MOPU)
```

```
      GO TO 8946
 3090 CONTINUE
      IF(CNAME.NE.NTM) GO TO 3100
C#####--- ERROR MONITOR OUTPUT ---#####
      CALL ERMONT(MOPU,ORNAME,PHIMAX)
      GO TO 8946
 3100 CONTINUE
      IF(CNAME.NE.NTRACK) GO TO 3110
C#####--- TRACK OUTPUT ---#####
      CALL TRACO(MOPU,CRNAME,DT)
      GO TO 8946
 3110 CONTINUE
      IF(CNAME.NE.NUOT1) GO TO 3120
C#####--- USER OUTPUT OPTION 1 ---#####
      WRITE(ITTY,8764)
      GO TO 8946
3120  CONTINUE
 8946 CONTINUE
 8943 CONTINUE
 8764 FORMAT(1H0,'THIS OPTION HAS NOT BEEN PROGRAMED YET')
      IF(MODE.EQ.2) GO TO 8749
      IF(OPTEST.EQ.NX) GO TO 8152
 8150 IF(IRUNS.EQ.LRUNS) GO TO 8152
      GO TO 8802
 8152 CONTINUE
      LRUNS=0
      GO TO 8749
C
C*****************************************************************************
C
C ******************
C *                *
C#####--- TERMINATE #####
C *                *
C ******************
 8809 OSECB=0
      CALL TIMDAT(JDATE,ITTY)
      IF(IRT.NE.1) GO TO 5607
      CALL HPOST(DONECB,'DN')
      CALL WAITRT(OSECB)
 5607 CONTINUE
      WRITE(ITTY,8821)
 8821 FORMAT(1H0,'PROGRAM TERMINATED')
      CALL RACN(1,IRACNE)
      CALL CHKIO
      CALL WRTOFF
      CALL RDOFF
      RETURN 4
      END
```

2.2 FUNCTIONS

PRESENTED HERE IS THE FORTRAN LISTING FOR THE FUNCTION SUBPROGRAMS CALLED BY THE MODEL SUBPROGRAM. THE FOLLOWING LIST DETAILS THE FUNCTION NAMES AND THEIR USE:

FUNCTION	USE
FF	Calculation of Front Wheel Brake Torque
FR	Calculation of Rear Wheel Brake Torque
FCSI	Calculation of the Wheel Slip Side Force Shaping Function
PTBAK	Calculation of a Caster Trail Function
GETDEL	Calculation of a rectangular bump grid for VHTP No. 3
XINT	Linear Interpolation of Function Values between Input Table Data Points
AMIN	Selection of the Minimum Value between Two Variables
POLY	Evaluation of a Fifth-Order Polynomial Approximation to a Function

```
C     FUNCTION FF(P)
      FUNCTION FF(P)
C*********************************************************************
C     THIS FUNCTION CALCULATES THE FRONT WHEEL BRAKE TORQUE
C*********************************************************************
      COMMON/NEWTBS/TQBF(20),PBF(20),TQBR(20),PBR(20),
     1PFA(20),GAMF(20),NTF,NTR,NFA
      FF=XINT(P,PBF,TQBF,NTF)
      RETURN
      END
```

```
C     FUNCTION FR(P)
      FUNCTION FR(P)
C***********************************************************************
C     THIS FUNCTION CALCULATES THE REAR WHEEL BRAKE TORQUE
C***********************************************************************
      COMMON/NEWTBS/TQBF(20),PBF(20),TQBR(20),PBR(20),
     1AFA(20),GAMF(20),NTF,NTR,NFA
      FR=XINT(P,PBR,TQBR,NTR)
      RETURN
      END
```

```
C     FUNCTION FCSI(GAMI,SLPI)
      FUNCTION FCSI(GAMI,SLPI)
C**********************************************************************
C     THIS FUNCTION CALCULATES THE WHEEL-SLIP SIDE FORCE
C     SHAPING FUNCTION
C**********************************************************************
      COMMON/NEWTBS/TQBF(20),PBF(20),TQBR(20),PBR(20),
     1AFA(20),GAMF(20),NTF,NTR,NFA
      TMP=ABS(SLPI)
      FCSI = XINT(TMP,GAMF,AFA,NFA)
      RETURN
      END
```

```
C     SUBROUTINE PTBAK(BET,FRI,AKKI,PTBI)
      SUBROUTINE PTBAK(BET,FRI,AKKI,PTBI)
C*************************************************************************
C     THIS FUNCTION CALCULATES CASTER TRAIL
C*************************************************************************
      COMMON/PTBK/AP1,AP2,AP3,AP4,AP5,BTC1,BTC2
      AP5=600.
      AKKI=AP4+FRI/AP5
      TEMP=ABS(BET*57,29578)
      PTBI=AP1
      IF(TEMP.LE.BTC1)RETURN
      PTBI=AP3
      IF(TEMP.GT.BTC2)RETURN
      PTBI=AP1*(1.0-(TEMP-BTC1)*AP2)
      RETURN
      END
```

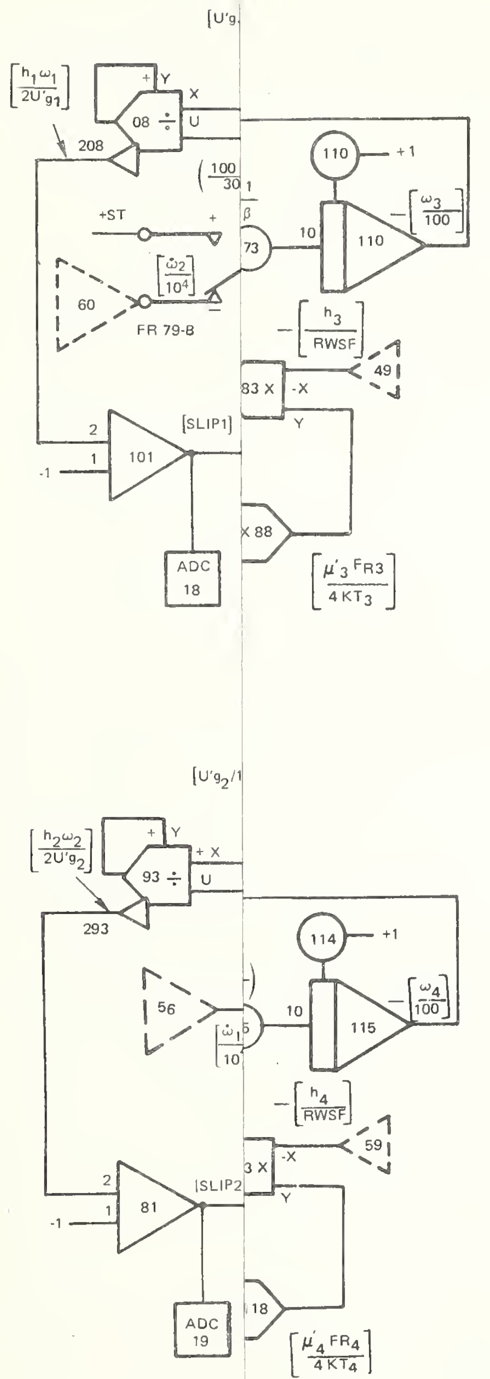
```
C     FUNCTION GETDEL(X,I,R5,NBMP)
      FUNCTION GETDEL(X,I,R5,NBMP)
C***********************************************************************
C     THIS SUBROUTINE PRODUCES THE BUMPS FOR VHTP #3
C***********************************************************************
      COMMON/XBS/XB(30),NS(4,30),DELX(4),XI(4),NNN
      COMMON/XYZ/NUMBR
      DIMENSION X(4)
      GETDEL=0.0
      DO 10 K=1,NBMP
      L=NBMP-K+1
      IF(X(I).LE.XB(L))NS(I,L)=NUMBR+NNN
      IF(X(I).GE.XB(L).AND.NUMBR.LE.NS(I,L))GO TO 20
   10 CONTINUE
      RETURN
   20 GETDEL=R5
      RETURN
      END
```

```
C      FUNCTION XINT(ARG,ARGTB,FUN,NP)
       FUNCTION XINT(ARG,ARGTB,FUN,NP)
C***********************************************************************
C      THIS FUNCTION PERFORMS LINEAR INTERPOLATION OF FUNCTION
C      VALUES BETWEEN INPUT TABLE DATA POINTS
C***********************************************************************
       DIMENSION ARGTB(NP),FUN(NP)
       DO 10 I=1,NP
       IF(ARG-ARGTB(I)) 30,20,10
   10  CONTINUE
       I=NP
   30  IF(I.EQ.1) I=2
       TEMP=(ARG-ARGTB(I-1))/(ARGTB(I)-ARGTB(I-1))
       XINT=FUN(I-1)+(FUN(I)-FUN(I-1))*TEMP
       RETURN
   20  XINT=FUN(I)
       RETURN
       END
```

```
C     FUNCTION AMIN(X,Y)
      FUNCTICN AMIN(X,Y)
C*************************************************************************
C     THIS FUNCTION SELECTS THE MINIMUM VALUE BETWEEN TWO VARIABLES
C*************************************************************************
      IF(X-Y)1,1,2
    1 AMIN=X
      RETURN
    2 AMIN=Y
      RETURN
      END
```

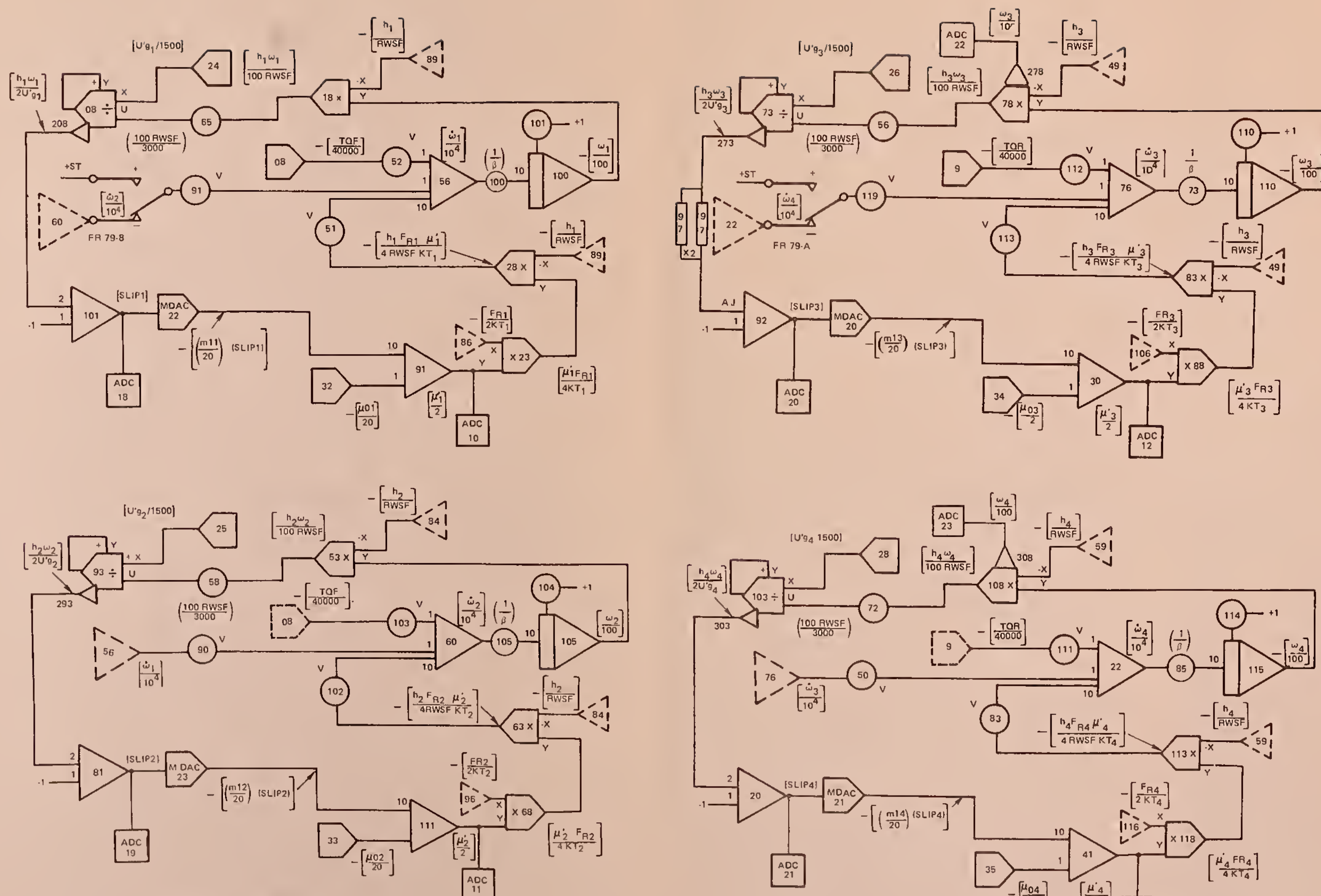
```
C     FUNCTION POLY(DL,TBL)
      FUNCTION POLY(DL,TBL)
C*********************************************************************
C     THIS FUNCTION EVALUATES A FIFTH-ORDED POLYNOMIAL
C     APPROXIMATION TO A FUNCTION
C*********************************************************************
      DIMENSION TBL(7)
      TMP=TBL(7)
      DO 10 I=1,6
      TMP=TMP*DL+TBL(7-I)
   10 CONTINUE
      POLY=TMP
      RETURN
      END
```

3. PRESENTED HERE ARE THE ANALOG COMPUTER DIAGRAMS



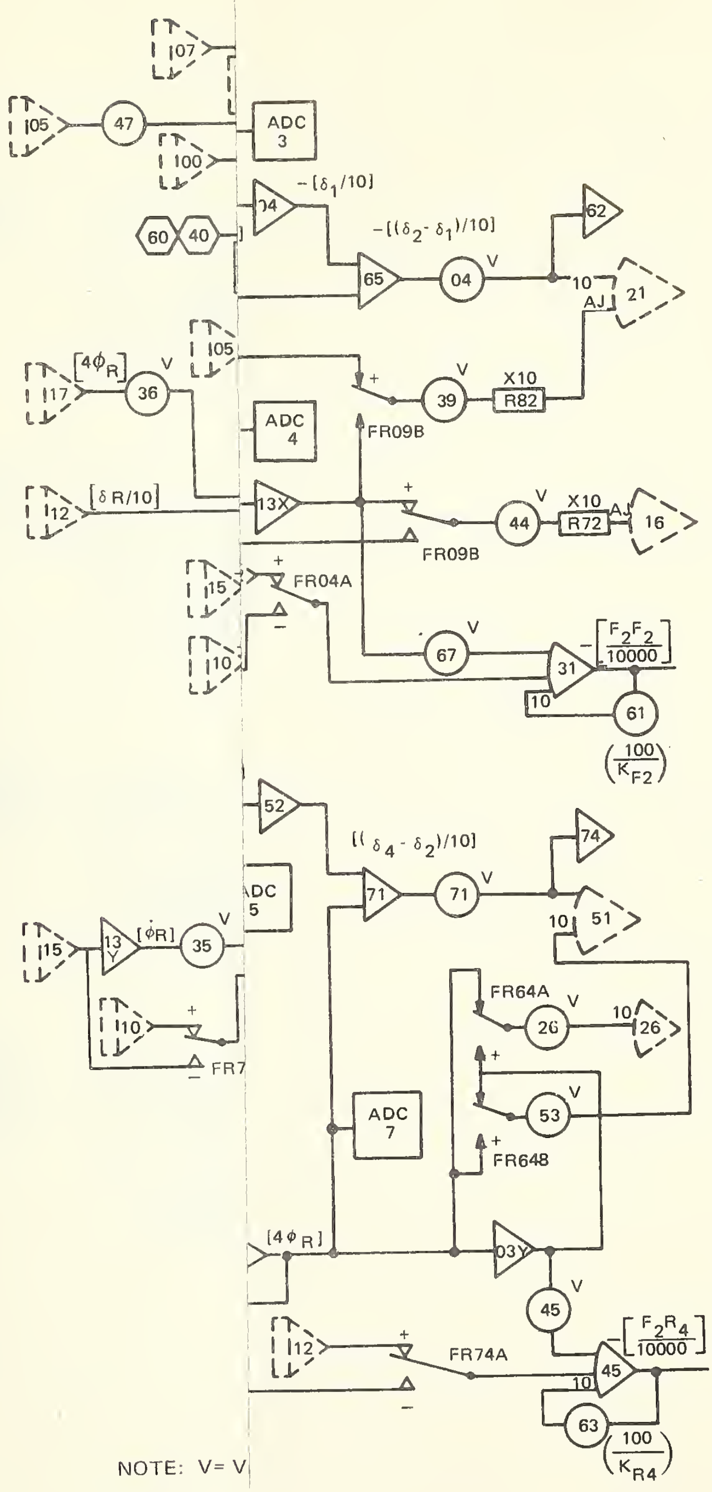
NOTE: V = \

l Wheel Dynamics



NOTE: V = VARIABLE POT SETTING

Fig. B-1 Analog Computer Diagram-Rotational Wheel Dynamics



-Suspension Forces and Deflections

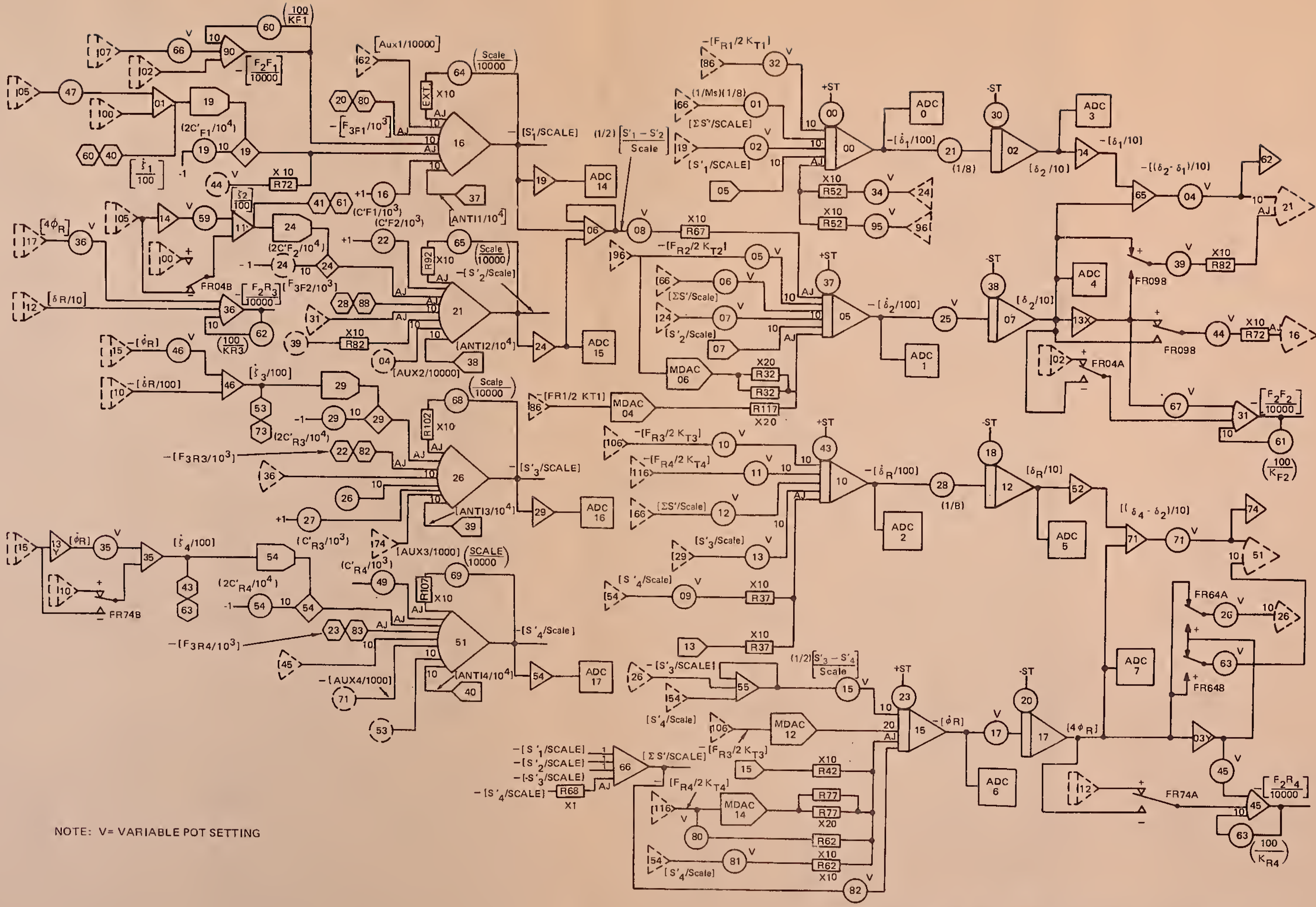


Fig. B-2 Analog Computer Diagram-Suspension Forces and Deflections

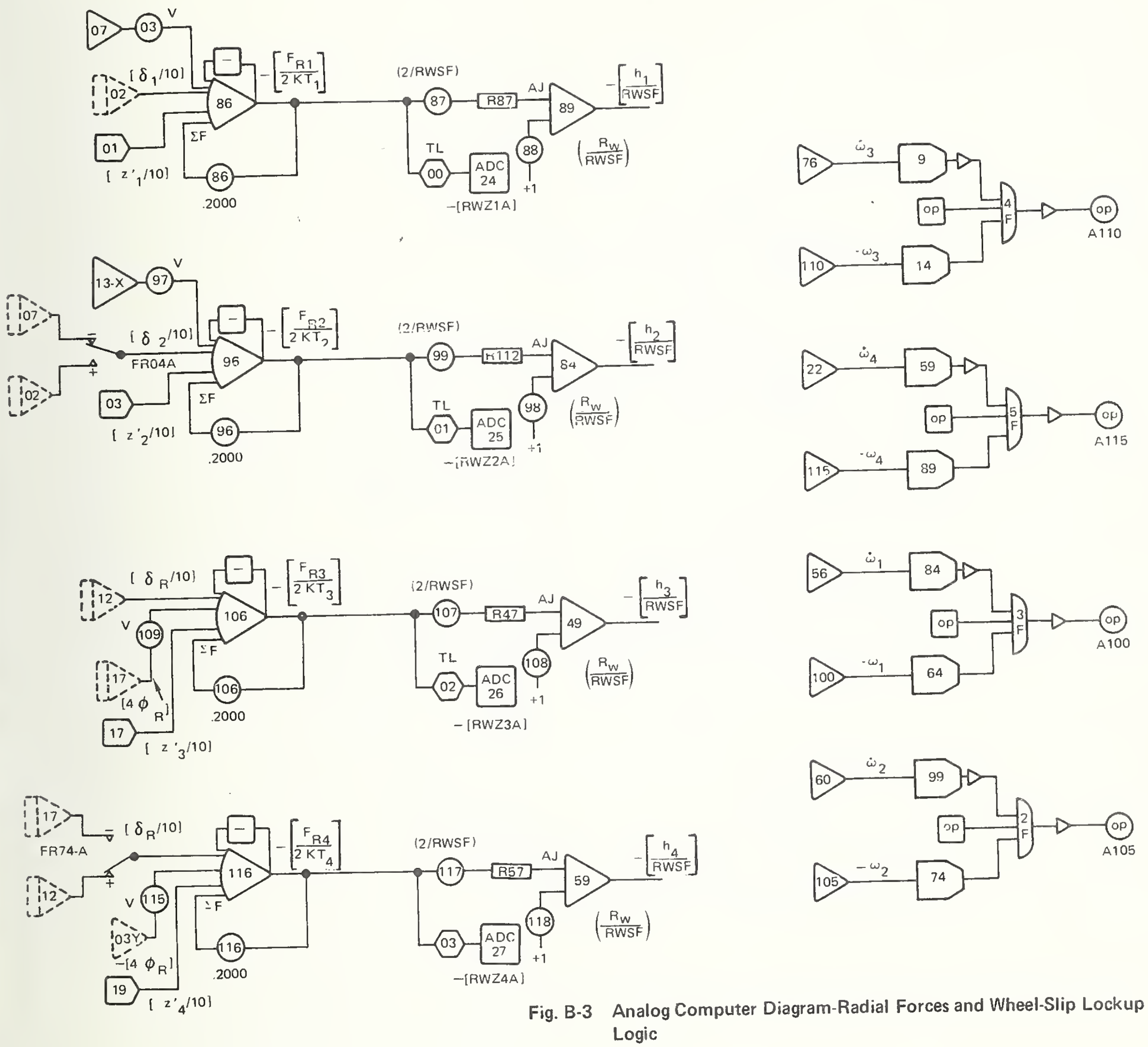
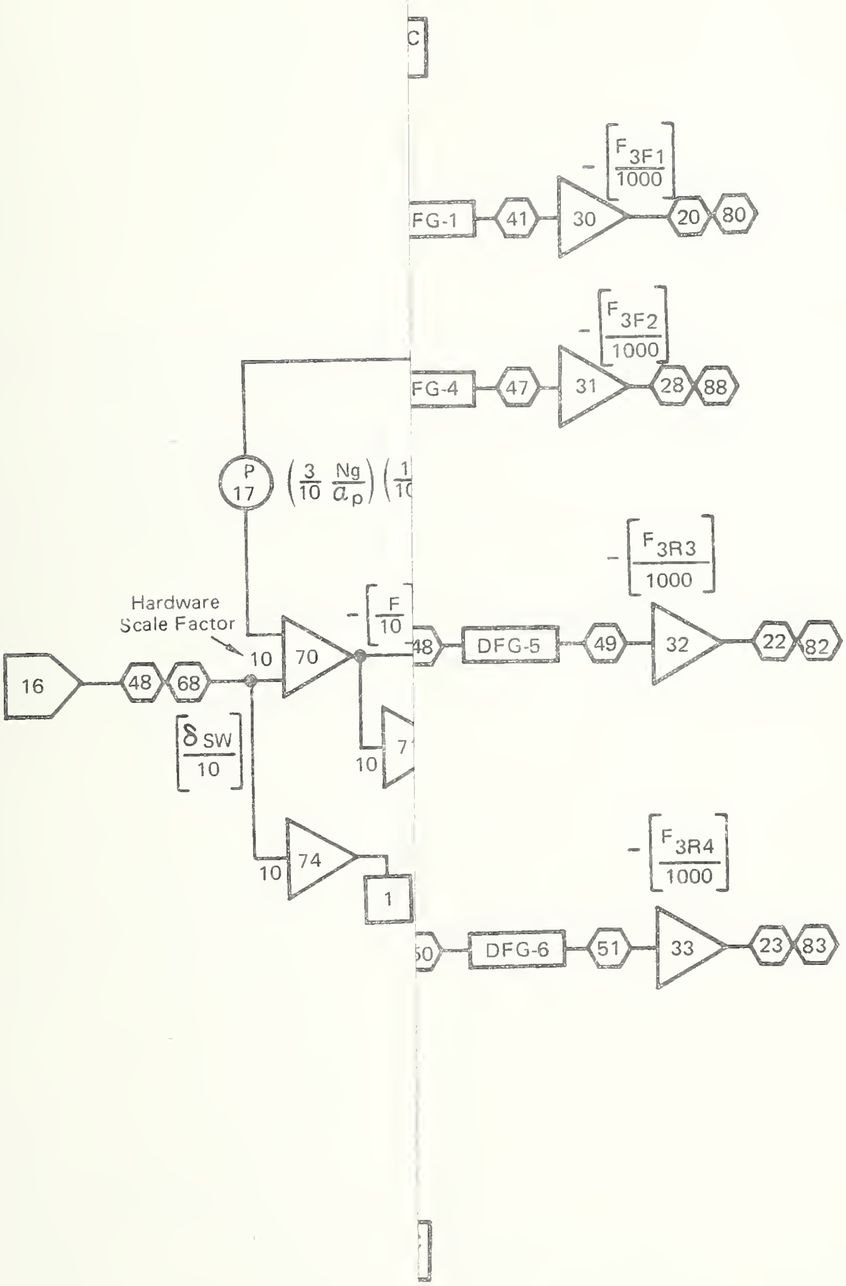


Fig. B-3 Analog Computer Diagram-Radial Forces and Wheel-Slip Lockup Logic



ering System and Shock Absorbers

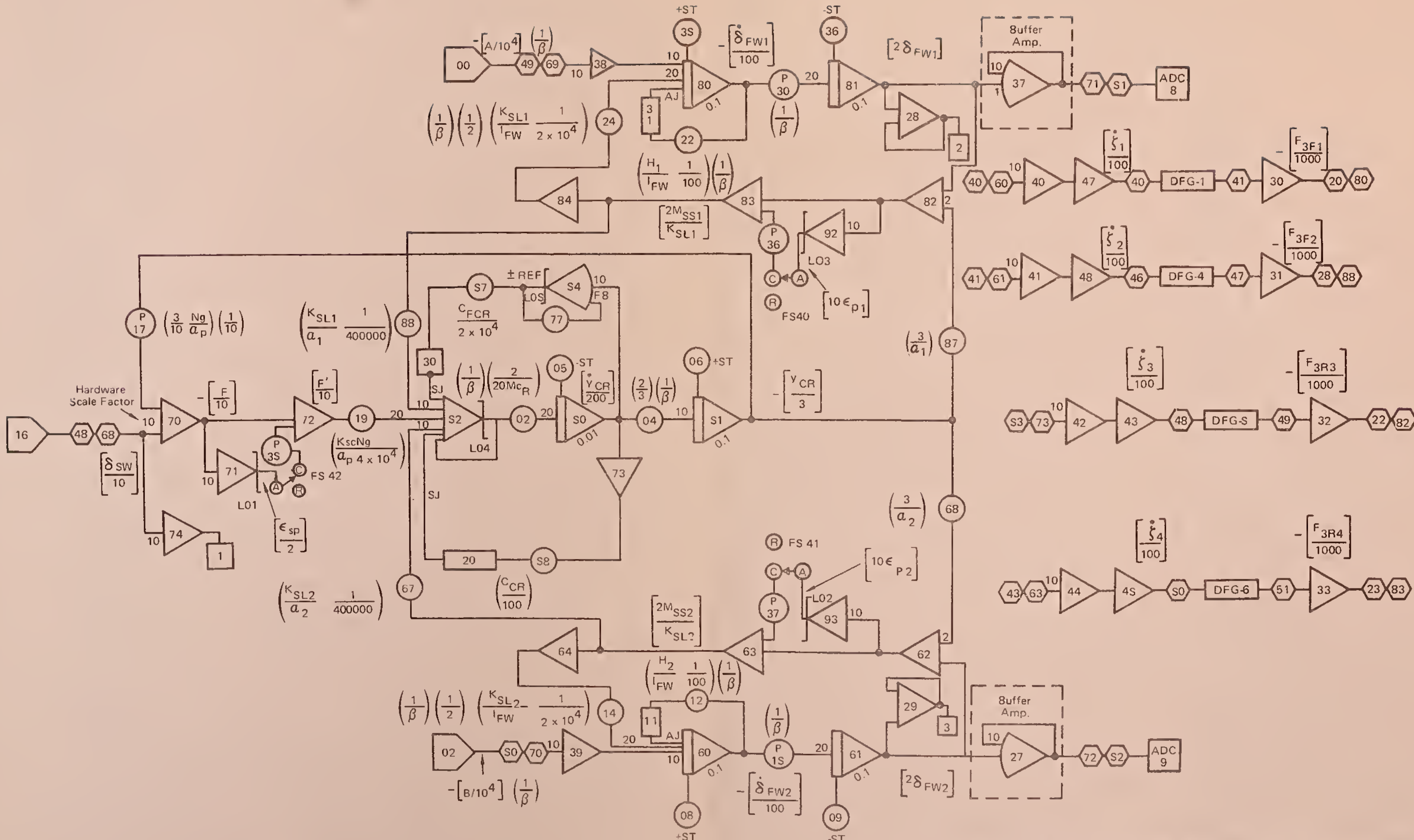


Fig. B-4 Analog Computer Diagram-Steering System and Shock Absorbers

4. PRESENTED HERE ARE THE SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS. THE ORDER OF THE PARAMETERS CORRESPONDS TO THE INPUT DATA CARDS.

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
001	MS	M_S	Total sprung mass ($lb\text{-}sec^2/in$)
002	MUF	M_{UF}	Total front unsprung mass ($lb\text{-}sec^2/in$)
003	MUR	M_{UR}	Total rear unsprung mass ($lb\text{-}sec^2/in$)
004	ZF	z_F	Static distance between c.g. of sprung mass and spin axis of front wheels in z-direction (in)
005	ZR	z_R	Static distance between c.g. of sprung mass and spin axis of rear wheels in z-direction (in)
006	A	a	Distance between c.g. of sprung mass and spin axis of front wheels in x-direction (in)
007	B	b	Distance between c.g. of sprung mass and spin axis of rear wheels in x-direction (in)
008	TF	T_F	Front tread width (in)
009	TR	T_R	Rear tread width (in)
010	TSR	T_{SR}	Distance between rear axle spring centers in y-direction (in)
011	IX	I_X	Roll moment of inertia of sprung mass ($lb\text{-}in\text{-}sec^2$)
012	IY	I_Y	Pitch moment of inertia of sprung mass ($lb\text{-}in\text{-}sec^2$)
013	IZ	I_Z	Yaw moment of inertia of sprung mass ($lb\text{-}in\text{-}sec^2$)

Symbols and Definitions of the Program Parameters
(continued)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
014	IXZ	I_{XZ}	Product of inertia of sprung mass ($lb\text{-}in\text{-}sec^2$)
015	IR	I_R	Moment of inertia of solid rear axle about a line through its center of gravity and parallel to the x-axis (exclude zero for computational purposes) ($lb\text{-}in\text{-}sec^2$)
016			Unassigned
017	RF	R_F	Auxiliary roll stiffness in front suspension (lb-in/rad)
018	STOP		Terminal velocity for simulation shutoff (mph)
019	AKF1	K_{F1}	Right front suspension spring rate (lb/in)
020	AKF2	K_{F2}	Left front suspension spring rate (lb/in)
021	AKR3	K_{R3}	Right rear suspension spring rate (lb/in)
022	AKR4	K_{R4}	Left rear suspension spring rate (lb/in)
023			Unassigned
024	RR	R_R	Auxiliary roll stiffness in rear suspension (lb-in/rad)
025	CF1P	C'_{F1}	Coulomb damping at right front wheel (lb)
026	CF2P	C'_{F2}	Coulomb damping at left front wheel (lb)
027	CR3P	C'_{R3}	Coulomb damping at right rear wheel (lb)
028	CR4P	C'_{R4}	Coulomb damping at left rear wheel (lb)

Symbols and Definitions of the Program Parameters
(continued)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
029	ZBAS	Z_{BIAS}	Bias constant to vertically shift the vehicle c.g. position (in)
030	KRS	K_{RS}	Roll steer coefficient of solid rear axle (rad/rad)
031	RW	R_W	Undeflected tire radius (in)
032	SCAL		Suspension force scale factor
033	FOT	$A\Omega_{TF}$	Proportionality factor defining limits of small-angle cornering and camber stiffness approximation, front wheels
034	A0	A_{0F}	Constant term in small-angle cornering stiffness function, front wheels (lb/rad)
035	A1	A_{1F}	Linear term coefficient in small-angle cornering stiffness function, front wheels (1/rad)
036	A2	A_{2F}	Quadratic term coefficient in small-angle cornering stiffness function, front wheels (lb)
037	A3	A_{3F}	Linear term coefficient in small-angle camber stiffness function, front wheels (1/rad)
038	A4	A_{4F}	Quadratic term coefficient in small-angle camber stiffness function, front wheels (lb)
039	TIR	T_{IR}	Distance in the y-direction between the centers of inside tires for solid rear axle with dual tires (in)

Symbols and Definitions of the Program Parameters
(continued)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
040	TOR	T_{OR}	Distance in the y-direction between the centers of outside tires for solid rear axle with dual tires (in)
041	KSC	K_{SC}	Steering column-gear flexibility (lb-in/rad)
042	NG	N_G	Gear ratio of steering gear box
043-046			Unassigned
047	IFW	I_{FW}	Moment of inertia of front wheel about the kingpin axis ($lb\text{-}in\text{-}sec^2$)
048	IF	I_F	Moment of inertia of solid front axle about a line through its center of gravity and parallel to the x-axis (exclude zero for computational purposes) ($lb\text{-}in\text{-}sec^2$)
049	IWF	I_{WF}	Moment of inertia of front wheel about its spin axis ($lb\text{-}in\text{-}sec^2$)
050	IWR	I_{WR}	Moment of inertia of rear wheel about its spin axis ($lb\text{-}in\text{-}sec^2$)
051	IDR	I_{DR}	Moment of inertia of rear drive line about its spin axis ($lb\text{-}in\text{-}sec^2$)
052	ARR	$\overline{AR}_R$	Rear wheel drive axle ratio

Symbols and Definitions of the Program Parameters
(continued)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
053	TSF	T_{SF}	Distance between front axle spring centers in y-direction (in)
054	KFS	K_{FS}	Roll steer coefficient of solid front axle (rad/rad)
055	PT	$\overline{PT}$	Front wheel caster trail (in)
056	YSA1	Y_{SA1}	Distance between kingpin axis and wheel center line, measured along wheel spin axis, right front (in)
057	YSA2	Y_{SA2}	Distance between kingpin axis and wheel center line, measured along wheel spin axis, left front (in)
058	PHS1	ϕ_{SA1}	Kingpin inclination angle, right front (rad)
059	PHS2	ϕ_{SA2}	Kingpin inclination angle, left front (rad)
060	CTSW		Caster trail switch: 060 = 1, constant; = 0, function
061	IDF	I_{DF}	Moment of inertia of front drive line about its spin axis (lb-in-sec^2)
062	ARF	$\overline{AR}_F$	Front wheel drive axle ratio
063 - 074			Initial conditions: $p,q,r,u,v,w,x,y,z,\theta,\phi,\psi$. Note that z_0 and θ_0 are computed values at t=0 and need not be specified

Symbols and Definitions of the Program Parameters
(continued)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
075	DT		Integration step size (sec)
076	TN		Maximum run time (sec)
077-078	KTI	K_{Ti}	Tire spring rate, front wheels (lb/in)
079-080	KTI	K_{Ti}	Tire spring rate, rear wheels (lb/in)
081-084	RPSI	ω_i	Initial wheel rotation rates computed at t=0 (rad/sec)
085	B1	B_{1F}	Load term coefficient of lateral friction coefficient, front tire (1/lb)
086	B2	B_{2F}	Velocity term coefficient of lateral friction coefficient, front tire (1/mph)
087	B3	B_{3F}	Constant term of lateral friction coefficient, front tire (dimensionless)
088	B4	B_{4F}	Quadratic load term coefficient of lateral friction coefficient, front tire ($1/lb^2$)
089-091			Initial conditions: $\dot{\delta}_i$
092	DELF	δ_{FIN}	Static displacement change in front suspension due to vehicle load configuration (in)
093	DELR	δ_{RIN}	Static displacement change in rear suspension due to vehicle load configuration (in)

Symbols and Definitions of the Program Parameters
(continued)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
094-106			Initial conditions: δ_i, $\dot{\phi}_R$, ϕ_R, δ_{FWi}, μ_{Xi}, S_i'
107	PPRT		Parameter table, print control: 107 = 0, no print; =1, print
108	FREQ		Sinusoidal steer frequency (hertz)
109	RWSF		Undeflected tire radius scale factor
110	TQMX		Maximum available drive torque (lb-in)
111	KTQ	K_{TQ}	Drive torque gain factor (lb-sec)
112	VC	V_C	Commanded velocity (mph)
113	MTSW		Front wheel kingpin moment switch: 113=1, in; =0, out
114	DSWM	δ_{SW}	Maximum steering wheel angle, except sinusoidal steer (degrees)
115	TST		Initial time of steer, except sinusoidal steer (sec)
116	DSLP		Time to achieve maximum steer angle, equivalent to steer rate, except sinusoidal steer (exclude zero for computational purposes) (sec)

Symbols and Definitions of the Program Parameters (continued)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
117	CGAM		Initial time of brake application, except drastic brake and steer (sec)
118	CS		Initial time of brake application, except drastic brake and steer (sec)
119	TQR	$\overline{TQ}_{Bi}$	Rear wheel brake torque (lb-in)
120	TQF	$\overline{TQ}_{Bi}$	Front wheel brake torque (lb-in)
121	PFL		Applied brake pressure (psi)
122	T1		Drive torque control (sec)
123	DSW		Sinusoidal steer amplitude (degrees)
124			Unassigned
125	ISW5		VHTP sinusoidal steer code: 125 = 0, disable; = 1, enable
126	SW15		VHTP roll over code: 126 = 0, disable; = 1, enable
127	PQSW		Equation suppress option: 127 = 0, none; = 1, $\dot{p} = 0$; =2, $\dot{q} = 0$; =3, $\dot{p} = \dot{q} = 0$
128	VTPS		VHTP switch
129	VHTP		VHTP index

Symbols and Definitions of the Program Parameters
(continued)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
130	AMCR	M_{CR}	Mass of steering system connecting rod (lb-sec^2/in)
131	ESP	ε_{SP}	Free play in steering gear box (rad)
132	KSL1	K_{SL1}	Steering linkage flexibility, right front wheel (lb-in/rad)
133	KSL2	K_{SL2}	Steering linkage flexibility, left front wheel (lb-in/rad)
134-135	AAI	a_{Li}	Length of steering linkage arms (in)
136	CCR	C_{CR}	Viscous damping coefficient of steering system connecting rod (lb-sec/in)
137	CFCR	C_{FCR}	Coulomb damping of steering system connecting rod (lb)
138	AP	a_P	Length of Pitman arm (in)
139-140	EPI	ε_{Pi}	Free play in steer of front wheel (rad)
141	AERO		Aerodynamic option: 141 = 0, no; = 1, yes
142	VYW	V_{yw}	Velocity of cross wind in space-fixed axes, measured at sprung mass c.g. (in/sec)
143	OMXW	ω_{xw}	Angular velocity of wind in space-fixed axes (rad/sec)
144	OMZW	ω_{zw}	Angular velocity of wind in space-fixed axes (rad/sec)

Symbols and Definitions of the Program Parameters
(continued)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
145	RHOA	ρ_a	Mass density of air (lb-sec^2/in^4)
146	CYP	C_{y_p}	Aerodynamic stability derivative of lateral force coefficient with respect to roll velocity
147	CYR	C_{y_r}	Aerodynamic stability derivative of lateral force coefficient with respect to yaw velocity
148	CZAL	C_{z_α}	Aerodynamic stability derivative of normal force coefficient with respect to aerodynamic angle of attack
149	CZQ	C_{z_q}	Aerodynamic stability derivative of normal force coefficient with respect to pitch velocity
150	CLP	C_{ℓ_p}	Aerodynamic stability derivative of rolling moment coefficient with respect to roll velocity
151	CLR	C_{ℓ_r}	Aerodynamic stability derivative of rolling moment coefficient with respect to yaw velocity
152	CMAL	C_{m_α}	Aerodynamic stability derivative of pitching moment coefficient with respect to aerodynamic angle of attack
153	CMQ	C_{m_q}	Aerodynamic stability derivative of pitching moment coefficient with respect to pitch velocity
154	CNP	C_{n_p}	Aerodynamic stability derivative of yawing moment coefficient with respect to roll velocity

Symbols and Definitions of the Program Parameters
(continued)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
155	CNR	C_{n_r}	Aerodynamic stability derivative of yawing moment coefficient with respect to yaw velocity
156	SF	S_f	Projected frontal area of vehicle, including tires and under-body parts; characteristic area upon which aerodynamic force and moment coefficients are based (in^2)
157	VLEN	ℓ_v	Vehicle length, characteristic length upon which aerodynamic moment coefficients are based (in)
158	REWV	R_{w_v}	Resultant wind velocity (in/sec)
159-168			Unassigned
169	SNT	$(SN)_T$	Tire data surface skid number
170	SNS0	$(SN)_{S0}$	Simulated vehicle surface skid number
171	SNS1	$(SN)_{S1}$	Simulated vehicle surface skid number
172	SNSW		Skid patch switch: 172 = 0, side approach; = 1, front approach; = 2, disable
173	DIST		Initial distance between car and skid patch (in)
174	PL		Skid patch length (in)
175	TSCP		Computer time scale factor
176-179			Unassigned

Symbols and Definitions of the Program Parameters
(continued)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
180	PASS		Number of passes through integration routine: =1, single; =2, double; =3, triple; =4, improved Euler method and analog radial forces.
181			Unassigned
182-185	SII	SI_i	Wheel slip ratio at which peak braking coefficient of friction occurs
186-191			Unassigned
192	MTQB		Brake force rate (exclude zero for computational purposes) (psi/sec)
193	DCSW		Driver control switch: 193 = 0, disable; 1, enable
194	LDF		Lateral displacement feedback gain (deg/in)
195	LDRF		Lateral displacement rate feedback gain (deg/in/sec)
196-197	EKI	$\Delta\psi_i$	Static front wheel toe bias angle (degrees)
198	BMPL		Length of single road bump (in)
199	BMPS		Distance between leading edges of consecutive rectangular road bumps (in)
200	BMPH		Road bump height (in)

Symbols and Definitions of the Program Parameters
(continued)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
201	XB		Initial distance from car to first bump (in)
202	APF1	P_{BP1}	Front tire peak braking coefficient of friction, constant term (dimensionless)
203	APF2	P_{BF2}	Front tire peak braking coefficient of friction, linear term coefficient (1/lb)
204	APR1	P_{BR1}	Rear tire peak braking coefficient of friction, constant term (dimensionless)
205	APR2	P_{BR2}	Rear tire peak braking coefficient of friction, linear term coefficient (1/lb)
206	MUSF	μ_{SF}	Front tire sliding coefficient of friction
207	MUSR	μ_{SR}	Rear tire sliding coefficient of friction
208	BCON		μ' beta constant
209	FCSW		Tire side force friction coefficient switch: 209 = 0, polynominal function; = 1, tabular function
210-218			Unassigned
219-220	FEEI	$\Delta\phi_i$	Front wheel camber bias angle (degrees)

Symbols and Definitions of the Program Parameters
(continued)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
221-222	THEI	$\Delta\theta_i$	Front wheel caster bias angle (degrees)
223-230			Unassigned
231-232	HI	H_i	Viscous damping derivative in front wheel (lb-in-sec/rad)
233	LAMD	λ_D	Drive torque distribution factor for four-wheel drive (note that $\lambda_D = 0$ for front wheel drive, and $\lambda_D = 1.0$ for rear wheel drive)
234-237			Unassigned
238-241	BRI	λ_{Bi}	Brake torque multiplier for wheel i
242	KCF	K_{CF}	Front lateral force compliance camber coefficient (rad/lb)
243	KCR	K_{CR}	Rear lateral force compliance camber coefficient (rad/lb)
244	KSR	K_{SR}	Rear aligning torque compliance steer coefficient (rad/(lb-in))
245	RB1	B_{1R}	Load term coefficient of lateral friction coefficient, rear tire (1/lb)
246	RB2	B_{2R}	Velocity term coefficient of lateral friction coefficient, rear tire (1/mph)
247	RB3	B_{3R}	Constant term of lateral friction coefficient, rear tire (dimensionless)

Symbols and Definitions of the Program Parameters
(continued)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
248	RB4	B_{4R}	Quadratic load term coefficient of lateral friction coefficient, rear tire ($1/lb^2$)
249	AFK1	A_{F1}	Aligning torque coefficient, front tire (in/lb)
250	AFK2	A_{F2}	Aligning torque coefficient, front tire (in/lb)
251	AFK3	A_{F3}	Aligning torque coefficient, front tire ($in/rad^{1/2}$)
252	ARK1	A_{R1}	Aligning torque coefficient, rear tire (in/lb)
253	ARK2	A_{R2}	Aligning torque coefficient, rear tire (in/lb)
254	ARK3	A_{R3}	Aligning torque coefficient, rear tire ($in/rad^{1/2}$)
255	OFC0	O_{F0}	Overturning moment coefficient, front tire (lb-in)
256	OFC1	O_{F1}	Overturning moment coefficient, front tire (in/lb)
257	OFC2	O_{F2}	Overturning moment coefficient, front tire (in/(lb-rad))
258	OFC3	O_{F3}	Overturning moment coefficient, front tire (in/rad)
259	ORC0	O_{R0}	Overturning moment coefficient, rear tire (lb-in)
260	ORC1	O_{R1}	Overturning moment coefficient, rear tire (in/lb)
261	ORC2	O_{R2}	Overturning moment coefficient, rear tire (in/(lb-rad))
262	ORC3	O_{R3}	Overturning moment coefficient, rear tire (in/rad)
263	CP0F	P_{F0}	Antipitch coefficient, front suspension (dimensionless)

Symbols and Definitions of the Program Parameters
(continued)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
264	CP1F	P_{F1}	Antipitch coefficient, front suspension (1/in)
265	CP2F	P_{F2}	Antipitch coefficient, front suspension ($1/in^2$)
266	CP0R	P_{R0}	Antipitch coefficient, rear suspension (dimensionless)
267	CP1R	P_{R1}	Antipitch coefficient, rear suspension (1/in)
268	CP2R	P_{R2}	Antipitch coefficient, rear suspension ($1/in^2$)
269	CR0F	R_{F0}	Antiroll coefficient, front suspension (dimensionless)
270	CR1F	R_{F1}	Antiroll coefficient, front suspension (1/in)
271	CR2F	R_{F2}	Antiroll coefficient, front suspension ($1/in^2$)
272	CR0R	R_{R0}	Antiroll coefficient, rear suspension (dimensionless)
273	CR1R	R_{R1}	Antiroll coefficient, rear suspension (1/in)
274	CR2R	R_{R2}	Antiroll coefficient, rear suspension ($1/in^2$)
275-276			Unassigned
277	BMPN		Number of bumps in bump grid
278	TQB0		Time of brake application in combined drastic brake and steer VHTP (sec)

Symbols and Definitions of the Program Parameters
(continued)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
279	TQB1		Time of brake release in combined drastic brake and steer VHTP (sec)
280-283			Unassigned
284	HFC	h_{FC}	Distance between ground and roll center of front independent suspension (set to zero for solid front axle configuration) (in)
285	HRC	h_{RC}	Distance between ground and roll center of rear independent suspension (set to zero for solid rear axle configuration) (in)
286	DRSW		Drive wheel: 286 = 0, rear wheel drive; = 1, four wheel drive
287	AXLE		Suspension configuration: 287 = 0, solid front/rear; = 1, independent front/solid rear; =2, independent front/rear
288	DUAL		Rear dual tire option: 288 = 0, no duals; = 1, duals
289	TIRE		Number of vehicle tires: 289 = 4, single rear tires; = 6, dual rear tires; = 10, double dual rear tires
290	ROT	$A_{\Omega_{TR}}$	Proportionality factor defining limits of small-angle cornering and camber stiffness approximation, rear wheels

Symbols and Definitions of the Program Parameters
(continued)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
291	RA0	A_{0R}	Constant term in small-angle cornering stiffness function, rear wheels (lb/rad)
292	RA1	A_{1R}	Linear term coefficient in small-angle cornering stiffness function, rear wheels (1/rad)
293	RA2	A_{2R}	Quadratic term coefficient in small-angle cornering stiffness function, rear wheels (lb)
294	RA3	A_{3R}	Linear term coefficient in small-angle camber stiffness function, rear wheels (1/rad)
295	RA4	A_{4R}	Quadratic term coefficient in small-angle camber stiffness function, rear wheels (lb)

5. PRESENTED HERE ARE THE SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS WHICH ARE VEHICLE DESCRIPTORS OR TIRE MODEL COEFFICIENTS.

SYMBOLS AND DEFINITIONS OF THE PROGRAM PARAMETERS

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
001	MS	M_S	Total sprung mass (lb-sec^2/in)
002	MUF	M_{UF}	Total front unsprung mass (lb-sec^2/in)
003	MUR	M_{UR}	Total rear unsprung mass (lb-sec^2/in)
004	ZF	z_F	Static distance between c.g. of sprung mass and spin axis of front wheels in z-direction (in)
005	ZR	z_R	Static distance between c.g. of sprung mass and spin axis of rear wheels in z-direction (in)
006	A	a	Distance between c.g. of sprung mass and spin axis of front wheels in x-direction (in)
007	B	b	Distance between c.g. of sprung mass and spin axis of rear wheels in x-direction (in)
008	TF	T_F	Front tread width (in)
009	TR	T_R	Rear tread width (in)
010	TSR	T_{SR}	Distance between rear axle spring centers in y-direction (in)
011	IX	I_X	Roll moment of inertia of sprung mass (lb-in-sec^2)
012	IY	I_Y	Pitch moment of inertia of sprung mass (lb-in-sec^2)
013	IZ	I_Z	Yaw moment of inertia of sprung mass (lb-in-sec^2)

Symbols and Definitions of the Program Parameters
(continued)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
014	IXZ	I_{XZ}	Product of inertia of sprung mass (lb-in-sec^2)
015	IR	I_R	Moment of inertia of solid rear axle about a line through its center of gravity and parallel to the x-axis (exclude zero for computational purposes) (lb-in-sec^2)
016			Unassigned
017	RF	R_F	Auxiliary roll stiffness in front suspension (lb-in/rad)
019	AKF1	K_{F1}	Right front suspension spring rate (lb/in)
020	AKF2	K_{F2}	Left front suspension spring rate (lb/in)
021	AKR3	K_{R3}	Right rear suspension spring rate (lb/in)
022	AKR4	K_{R4}	Left rear suspension spring rate (lb/in)
024	RR	R_R	Auxiliary roll stiffness in rear suspension (lb-in/rad)
025	CF1P	C'_{F1}	Coulomb damping at right front wheel (lb)
026	CF2P	C'_{F2}	Coulomb damping at left front wheel (lb)
027	CR3P	C'_{R3}	Coulomb damping at right rear wheel (lb)
028	CR4P	C'_{R4}	Coulomb damping at left rear wheel (lb)

Symbols and Definitions of the Program Parameters
(continued)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
030	KRS	K_{RS}	Roll steer coefficient of solid rear axle (rad/rad)
031	RW	R_W	Undeflected tire radius (in)
033	FOT	$A\Omega_{TF}$	Proportionality factor defining limits of small-angle cornering and camber stiffness approximation, front wheels
034	A0	A_{0F}	Constant term in small-angle cornering stiffness function, front wheels (lb/rad)
035	A1	A_{1F}	Linear term coefficient in small-angle cornering stiffness function, front wheels (1/rad)
036	A2	A_{2F}	Quadratic term coefficient in small-angle cornering stiffness function, front wheels (lb)
037	A3	A_{3F}	Linear term coefficient in small-angle camber stiffness function, front wheels (1/rad)
038	A4	A_{4F}	Quadratic term coefficient in small-angle camber stiffness function, front wheels (lb)
039	TIR	T_{IR}	Distance in the y-direction between the centers of inside tires for solid rear axle with dual tires (in)
040	TOR	T_{OR}	Distance in the y-direction between the centers of outside tires for solid rear axle with dual tires (in)

Symbols and Definitions of the Program Parameters (continued)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
041	KSC	K_{SC}	Steering column-gear flexibility (lb-in/rad)
042	NG	N_G	Gear ratio of steering gear box
047	IFW	I_{FW}	Moment of inertia of front wheel about the kingpin axis ($lb\text{-}in\text{-}sec^2$)
048	IF	I_F	Moment of inertia of solid front axle about a line through its center of gravity and parallel to the x-axis (exclude zero for computational purposes) ($lb\text{-}in\text{-}sec^2$)
049	IWF	I_{WF}	Moment of inertia of front wheel about its spin axis ($lb\text{-}in\text{-}sec^2$)
050	IWR	I_{WR}	Moment of inertia of rear wheel about its spin axis ($lb\text{-}in\text{-}sec^2$)
051	IDR	I_{DR}	Moment of inertia of rear drive line about its spin axis ($lb\text{-}in\text{-}sec^2$)
052	ARR	$\overline{AR}_R$	Rear wheel drive axle ratio
053	TSF	T_{SF}	Distance between front axle spring centers in y-direction (in)
054	KFS	K_{FS}	Roll steer coefficient of solid front axle (rad/rad)

Symbols and Definitions of the Program Parameters
(continued)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
055	PT	$\overline{PT}$	Front wheel caster trail (in)
056	YSA1	Y_{SA1}	Distance between kingpin axis and wheel center line, measured along wheel spin axis, right front (in)
057	YSA2	Y_{SA2}	Distance between kingpin axis and wheel center line, measured along wheel spin axis, left front (in)
058	PHS1	ϕ_{SA1}	Kingpin inclination angle, right front (rad)
059	PHS2	ϕ_{SA2}	Kingpin inclination angle, left front (rad)
061	IDF	I_{DF}	Moment of inertia of front drive line about its spin axis (lb-in-sec^2)
062	ARF	$\overline{AR}_F$	Front wheel drive axle ratio
077-078	KTI	K_{Ti}	Tire spring rate, front wheels (lb/in)
079-080	KTI	K_{Ti}	Tire spring rate, rear wheels (lb/in)
085	B1	B_{1F}	Load term coefficient of lateral friction coefficient, front tire (1/lb)
086	B2	B_{2F}	Velocity term coefficient of lateral friction coefficient, front tire (1/mph)

Symbols and Definitions of the Program Parameters
(continued)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
087	B3	B_{3F}	Constant term of lateral friction coefficient, front tire (dimensionless)
088	B4	B_{4F}	Quadratic load term coefficient of lateral friction coefficient, front tire (1/lb^2)
092	DELF	δ_{FIN}	Static displacement change in front suspension due to vehicle load configuration (in)
093	DELR	δ_{RIN}	Static displacement change in rear suspension due to vehicle load configuration (in)
130	AMCR	M_{CR}	Mass of steering system connecting rod (lb-sec^2/in)
131	ESP	ε_{SP}	Free play in steering gear box (rad)
132	KSL1	K_{SL1}	Steering linkage flexibility, right front wheel (lb-in/rad)
133	KSL2	K_{SL2}	Steering linkage flexibility, left front wheel (lb-in/rad)
134-135	AAI	a_{Li}	Length of steering linkage arms (in)
136	CCR	C_{CR}	Viscous damping coefficient of steering system connecting rod (lb-sec/in)

Symbols and Definitions of the Program Parameters
(continued)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
137	CFCR	C_{FCR}	Coulomb damping of steering system connecting rod (lb)
138	AP	a_p	Length of Pitman arm (in)
139-140	EPI	ε_{Pi}	Free play in steer of front wheel (rad)
142	VYW	V_{yw}	Velocity of cross wind in space-fixed axes, measured at sprung mass c.g. (in/sec)
143	OMXW	ω_{xw}	Angular velocity of wind in space-fixed axes (rad/sec)
144	OMZW	ω_{zw}	Angular velocity of wind in space-fixed axes (rad/sec)
145	RHOA	ρ_a	Mass density of air (lb-sec^2/in^4)
146	CYP	C_{y_p}	Aerodynamic stability derivative of lateral force coefficient with respect to roll velocity
147	CYR	C_{y_r}	Aerodynamic stability derivative of lateral force coefficient with respect to yaw velocity
148	CZAL	C_{z_α}	Aerodynamic stability derivative of normal force coefficient with respect to aerodynamic angle of attack

Symbols and Definitions of the Program Parameters
(continued)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
149	CZQ	C_{z_q}	Aerodynamic stability derivative of normal force coefficient with respect to pitch velocity
150	CLP	C_{ℓ_p}	Aerodynamic stability derivative of rolling moment coefficient with respect to roll velocity
151	CLR	C_{ℓ_r}	Aerodynamic stability derivative of rolling moment coefficient with respect to yaw velocity
152	CMAL	C_{m_α}	Aerodynamic stability derivative of pitching moment coefficient with respect to aerodynamic angle of attack
153	CMQ	C_{m_q}	Aerodynamic stability derivative of pitching moment coefficient with respect to pitch velocity
154	CNP	C_{n_p}	Aerodynamic stability derivative of yawing moment coefficient with respect to roll velocity
155	CNR	C_{n_r}	Aerodynamic stability derivative of yawing moment coefficient with respect to yaw velocity
156	SF	S_f	Projected frontal area of vehicle, including tires and under-body parts; characteristic area upon which aerodynamic force and moment coefficients are based (in^2)

Symbols and Definitions of the Program Parameters (continued)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
157	VLEN	ℓ_V	Vehicle length, characteristic length upon which aerodynamic moment coefficients are based (in)
158	REWV	R_{W_V}	Resultant wind velocity (in/sec)
169	SNT	$(SN)_T$	Tire data surface skid number
170	SNS0	$(SN)_{S0}$	Simulated vehicle surface skid number
171	SNS1	$(SN)_{S1}$	Simulated vehicle surface skid number
182-185	SII	SI_i	Wheel slip ratio at which peak braking coefficient of friction occurs
196-197	EKI	$\Delta\psi_i$	Static front wheel toe bias angle (degrees)
202	APF1	P_{BP1}	Front tire peak braking coefficient of friction, constant term (dimensionless)
203	APF2	P_{BF2}	Front tire peak braking coefficient of friction, linear term coefficient (1/lb)
204	APR1	P_{BR1}	Rear tire peak braking coefficient of friction, constant term (dimensionless)

Symbols and Definitions of the Program Parameters
(continued)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
205	APR2	P_{BR2}	Rear tire peak braking coefficient of friction, linear term coefficient (1/lb)
206	MUSF	μ_{SF}	Front tire sliding coefficient of friction
207	MUSR	μ_{SR}	Rear tire sliding coefficient of friction
219-220	FEEI	$\Delta\phi_i$	Front wheel camber bias angle (degrees)
221-222	THEI	$\Delta\theta_i$	Front wheel caster bias angle (degrees)
231-232	HI	H_i	Viscous damping derivative in front wheel (lb-in-sec/rad)
242	KCF	K_{CF}	Front lateral force compliance camber coefficient (rad/lb)
243	KCR	K_{CR}	Rear lateral force compliance camber coefficient (rad/lb)
244	KSR	K_{SR}	Rear aligning torque compliance steer coefficient (rad/(lb-in))
245	RB1	B_{1R}	Load term coefficient of lateral friction coefficient, rear tire (1/lb)
246	RB2	B_{2R}	Velocity term coefficient of lateral friction coefficient, rear tire (1/mph)

Symbols and Definitions of the Program Parameters
(continued)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
247	RB3	B_{3R}	Constant term of lateral friction coefficient, rear tire (dimensionless)
248	RB4	B_{4R}	Quadratic load term coefficient of lateral friction coefficient, rear tire ($1/lb^2$)
249	AFK1	A_{F1}	Aligning torque coefficient, front tire (in/lb)
250	AFK2	A_{F2}	Aligning torque coefficient, front tire (in/lb)
251	AFK3	A_{F3}	Aligning torque coefficient, front tire ($in/rad^{1/2}$)
252	ARK1	A_{R1}	Aligning torque coefficient, rear tire (in/lb)
253	ARK2	A_{R2}	Aligning torque coefficient, rear tire (in/lb)
254	ARK3	A_{R3}	Aligning torque coefficient, rear tire ($in/rad^{1/2}$)
255	OFC0	O_{F0}	Overturning moment coefficient, front tire (lb-in)
256	OFC1	O_{F1}	Overturning moment coefficient, front tire (in/lb)
257	OFC2	O_{F2}	Overturning moment coefficient, front tire (in/(lb-rad))
258	OFC3	O_{F3}	Overturning moment coefficient, front tire (in/rad)
259	ORC0	O_{R0}	Overturning moment coefficient, rear tire (lb-in)

Symbols and Definitions of the Program Parameters
(continued)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
260	ORC1	O_{R1}	Overturning moment coefficient, rear tire (in/lb)
261	ORC2	O_{R2}	Overturning moment coefficient, rear tire (in/(lb-rad))
262	ORC3	O_{R3}	Overturning moment coefficient, rear tire (in/rad)
263	CP0F	P_{F0}	Antipitch coefficient, front suspension (dimensionless)
264	CP1F	P_{F1}	Antipitch coefficient, front suspension (1/in)
265	CP2F	P_{F2}	Antipitch coefficient, front suspension ($1/in^2$)
266	CP0R	P_{R0}	Antipitch coefficient, rear suspension (dimensionless)
267	CP1R	P_{R1}	Antipitch coefficient, rear suspension (1/in)
268	CP2R	P_{R2}	Antipitch coefficient, rear suspension ($1/in^2$)
269	CR0F	R_{F0}	Antiroll coefficient, front suspension (dimensionless)
270	CR1F	R_{F1}	Antiroll coefficient, front suspension (1/in)
271	CR2F	R_{F2}	Antiroll coefficient, front suspension ($1/in^2$)
272	CR0R	R_{R0}	Antiroll coefficient, rear suspension (dimensionless)

Symbols and Definitions of the Program Parameters
(continued)

Parameter Number	Symbol: Table	Symbol: Equation	Definition or Function (Units)
273	CR1R	R_{R1}	Antiroll coefficient, rear suspension (1/in)
274	CR2R	R_{R2}	Antiroll coefficient, rear suspension (1/in^2)
284	HFC	h_{FC}	Distance between ground and roll center of front independent suspension (set to zero for solid front axle configuration) (in)
285	HRC	h_{RC}	Distance between ground and roll center of rear independent suspension (set to zero for solid rear axle configuration) (in)
290	ROT	$A_{\Omega_{TR}}$	Proportionality factor defining limits of small-angle cornering and camber stiffness approximation, rear wheels
291	RA0	A_{0R}	Constant term in small-angle cornering stiffness function, rear wheels (lb/rad)
292	RA1	A_{1R}	Linear term coefficient in small-angle cornering stiffness function, rear wheels (1/rad)
293	RA2	A_{2R}	Quadratic term coefficient in small-angle cornering stiffness function, rear wheels (lb)
294	RA3	A_{3R}	Linear term coefficient in small-angle camber stiffness function, rear wheels (1/rad)
295	RA4	A_{4R}	Quadratic term coefficient in small-angle camber stiffness function, rear wheels (lb)

APPENDIX C
DESCRIPTION OF HYBRID COMPUTER SIMULATION LABORATORY

HYBRID COMPUTER

Figure C-1 is a diagram of the APL/JHU hybrid computer system. The primary units are the analog and digital computers, the hybrid control and data interface, the hybrid operators control console, and the remote batch station. Two types of analog computers manufactured by Electronic Associates, Inc., are located in the hybrid laboratory and the portion of the model programmed on the analog computer is divided between them. The entire steering system is contained on an EAI 231-R and the rotational wheel dynamics, circumferential friction coefficient calculation, tire deflection, and suspension dynamics is contained on an EAI 680.

The hybrid data and control interface permits control of the analog computer by the digital computer and exchange of data between the analog and digital computers. Data communication with the digital computer is provided by 24 multiplying digital-to-analog converters (MDAC's), 24 non-multiplying DAC's and 48 channels of analog-to-digital conversion (ADC's). The system contains a control interface which allows complete control of the 680 analog computer and data interface via Fortran IV callable subroutines by the digital computer which is remotely located 1000 feet from the hybrid laboratory. A detailed description of the APL/JHU hybrid facility is presented in Appendix C of Reference [3].

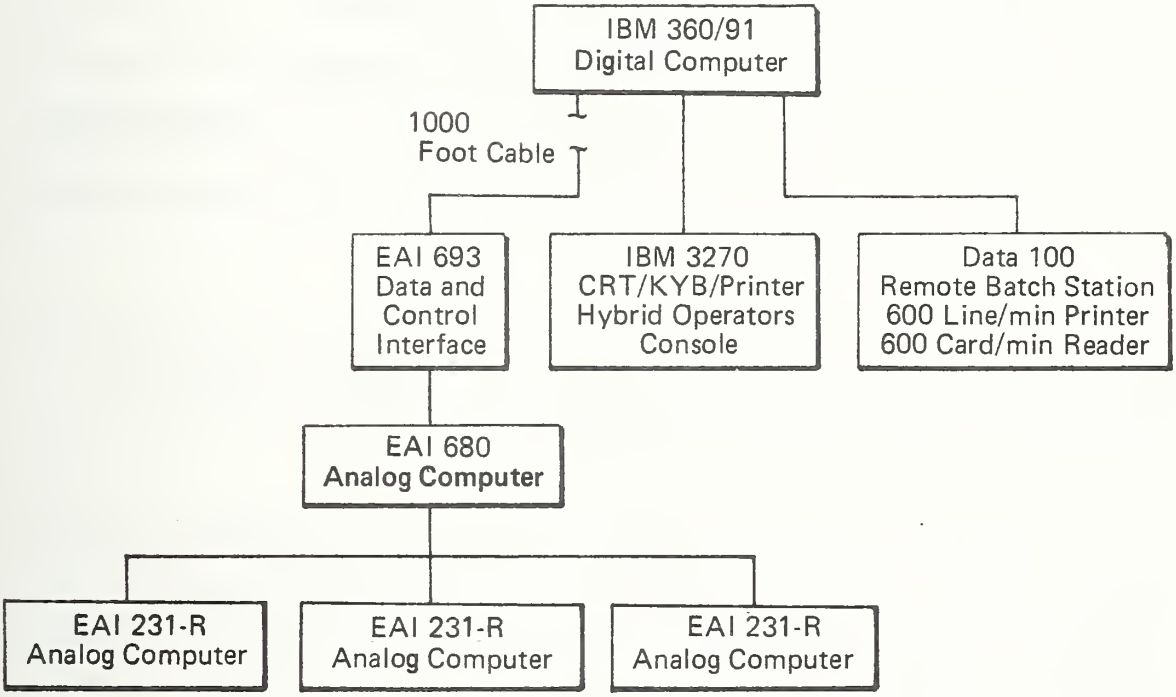


Fig. C-1 APL/JHU HYBRID COMPUTER SYSTEM BLOCK DIAGRAM

The digital computer is an IBM 360 Model 91. This is one of the largest and fastest computers built by IBM and is characterized by the following:

Third generation hardware

4 million bytes of main core storage

4 billion bytes of random access storage

Minimum instruction execution time of 60 nanoseconds

Use of the Operating System OS/MVT (Multi-programming with a Variable Number of Tasks).

All vehicle model calculations not assigned to the analog computers are performed digitally. Simulation coding is performed in the Fortran IV language.

Since the hybrid computing facility is remotely located from the digital computer, a remote batch terminal is required for program deck submission and printing of digital output. The terminal used in the hybrid laboratory is manufactured by Data 100 and contains a 600 card/minute reader and a 600 line/minute printer.

The hybrid operators control console is an IBM 3270 display system consisting of a CRT, keyboard, and printer. All simulation control is exercised at this station. Simulation directives, user information input via the keyboard and simulation output appear on the CRT. The printer is used to ghost print everything that appears on the CRT so

that user/computer transactions are not lost. A very powerful and flexible set of communication routines, designed for simulation use, is available to the user at the hybrid operators console. The software that services the hybrid operators control console is applicable to terminals other than IBM 3270. Therefore, remote operation of the simulation via a dial-up typewriter of CRT type terminal from a remote location is possible.

APPENDIX D
INTERACTIVE SUBROUTINES

1. INTRODUCTION

A set of generalized user communication subroutines has been added to the HVHP to enhance its operation by engineers. A subset of these routines directly aimed at the engineering user expedite the simulation functions of changing parameters, selecting variables for output, performing parametric runs, and general simulation control. Another subset, directed toward the simulation designer, allows tasks such as reassigning and rescaling analog-to-digital and digital-to-analog converters, printing the current values of all digital variables, and printing selected members of arrays. The use of these routines has allowed easy configuration of the HVHP to perform the vehicle handling test procedures (VHTP) and to calculate the vehicle comparison variables (CV).

2. SUBROUTINE USE

All simulation control occurs at the hybrid operator's station which consists of a telecommunications device (teletypewriter or a CRT with keyboard). Once the simulation is active, the user controls simulation activity with input responses to the OPTION cue. Each input selects an interactive routine. Once a routine has been selected, the user is queried for information necessary to perform the task of the selected routine. When the routine is completed, the readiness of the simulation for the next routine is indicated by the reappearance of the OPTION cue. Table I lists the names of the currently available interactive subroutines.

TABLE I

INTERACTIVE SUBROUTINE LIST

X (Execute Single Simulation Run)

XM (Execute Multi-run Series)

IC (Initialize Simulation)

F (Read or Alter Real Variables)

I (Read or Alter Integer Variables)

DACA (Alter DAC Array)

ADCA (Alter ADC Array)

MULTI (Setup Multiple Runs)

TEST (Test Runs)

MES (Send Message to Line Printer)

TABLE (Setup End-of-Run Output)

TRACK (Setup during Run Data Collection)

LA (List Array Values)

REMOVE (Suspend Output)

T+D (Output Time and Date)

STD (Standard Output)

DUMP (Output All Variables)

DACL (List DAC Array)

ADCL (List ADC Array)

TERM (Terminate Program)

In general the routines either alter simulation data, provide simulation control, or provide for output of simulation data. For output, the information may be directed to the hybrid operators station (T), the system line printer (L) or both (B). Also, the output can be specified as immediate (XEQ), at the end of a single run execution (S), or at the end of each run in a multiple-run execution (M). These output selections and their codes are shown in Table II.

Table II

Data Output Selections

Unit	Mode
T = CRT	S = Single Runs Only
L = System Line Printer	M = Multi-runs Only
B = Both T and L	A = Both S and M
	XEQ = Immediately

3. INTERACTIVE VARIABLES

To be effective, the routines must access, by name, the Fortran variables within a simulation. The variables of interest, termed interactive variables, need only appear in a Fortran named COMMON to be accessed. Once selected, a variable can be given any number of aliases. The alias capability is particularly important when an interactive variable is an array member. For instance, the current value of input brake line pressure, which is stored in element 121 of the PARAM array, has been given the alias PFL. Also, the PARAM array has been given the shorter alias PRM. A maximum of 400 interactive variables can be selected. However, it is important to note that the PARAM array, which has 295 elements, uses only one interactive variable allocation. Nearly all

variables which are associated with wheel computation (side force, FSI; normal force, FRI; ground patch velocity, CVI; etc.) are addressable as arrays and use only one interactive variable allocation. Currently, 300 interactive names have been used which permit the interrogation or alteration of more than 900 Fortran variables.

Each subroutine is discussed, including all required inputs, and actual user examples are presented. In the example, **** indicates user input. The remainder is computer output. Although it is not presented, the routines have extensive error handling facilities which prompt a user when errors are made.

4. SUBROUTINE DESCRIPTIONS

X (Execute Single Run)

Purpose - Perform a single simulation run. The simulation is automatically initialized (IC) and a run performed.

OPTION when the run is completed and all output has been printed.

Example -

```
OPTION
****   X
JUNE       20  1974
TIME   10:18:17.09
RUN    5 HAS STARTED
OUTPUT BELOW
 AXAV=    0.0    DECL TIME=    0.000 AVCUR=    0.118 BTDMAX=    0.023 BTMAX=    0.007 DELBT=    0.008
AYMAX=    0.154 PHIMAX=    1.502 RMAX=    0.088 LANE CHNG DEL=    0.0    DELPSI=    0.0    MAX STEER=   27.927
FTRQMAX=    0.0    RTRQMAX=    0.0

OPTION
```

XM (Execute Multi-run Series)

Purpose - Perform a series of parametric runs. The simulation is automatically initialized (IC) prior to each run in the series being performed.

Input Requested - None. Control is returned to OPTION when the run series is completed and all output has been printed.

Example -

```
OPTION
****  XM
JUNE       20  1974
TIME  10:24: 7.18
RUN  10 HAS STARTED
OUTPUT BELOW
MULTI TOTAL STR4..(    1) BETAMX(    1) BETDMX(    1) CUVRAT(    1)
  1     10        28.0        0.674E-02     0.237E-01     0.111
  2     11        56.0        0.141E-01     0.465E-01     0.209
  3     12        84.0        0.254E-01     0.655E-01     0.306
  4     13        112.        0.416E-01     0.903E-01     0.394
```

IC (Initialize Simulation, DO NOT Execute)

Purpose - Resets variables back to their initial conditions. Sets potentiometers and DAC's, then returns control to OPTION.

Internal Input Requested - None.

Example -

```
OPTION
****  IC
OPTION
```

F (Alter or Read Real Variables)

Purpose - Read current values of parameters, initial conditions, and variables which are declared "REAL" to Fortran. Alter current values of "REAL" parameters and initial conditions.

Input Requested - Interactive variable only for readout, interactive variable followed by new value for altering data.

Variation - Array Readout: (a) Interactive variable followed by range of array to be output, (b) interactive variable followed by the letters AM, allows addressing array elements by number.

Examples -

```
OPTION
****   F
ENTER
****   VHTPNO
  0.0
****   VHTPNO 5.
****   FRI 1 4
   1==>  1073.          2==>  1073.          3==>  887.7          4==>  887.7
****   PRM 285 287
 285==>  3.900        286==> 0.0           287==>  1.000
****   PRM 1 23
   1==>  12.33          2==> 0.5100          3==> 0.8200          4==>  11.30
   5==>  11.30          6==>  49.30          7==>  68.70          8==>  59.80
   9==>  61.80         10==>  47.00         11==>  3758.         12==> 0.2305E 05
  13==> 0.2333E 05     14==>  530.0         15==>  550.0         16==> 0.0
  17==> 0.4040E 05     18==>  40.00         19==>  105.0         20==>  2.000
  21==> -2.400         22==>  2.100         23==> 0.0
```

```
**** FRI AM
**** 1
   1073.
**** 2
   1073.
**** 3
   887.7
**** 4
   887.7
**** PRM AM
**** 285
   3.900
**** 205 4.
**** 285
   4.400
****
```

I (Alter or Read Integer Variables)

Purpose - Read current values of parameters, initial conditions and variables which are declared INTEGER to Fortran. Alter current values of INTEGER parameters and initial conditions.

Input Requested - Interactive variable only for readout, interactive variable followed by new value for altering data.

Example -

```
OPTION
**** I
ENTER
**** IPOT
     283
****
```

DACA (Alter DAC Array)

Purpose - To change DAC variable assignment and/or scaling.

Inputs Requested

1) "ENTER DAC NUM OR NAME"

   (a) Purpose - To select DAC to be altered.

   (b) Input Requested - The name of any interactive variable that is assigned to a DAC or a number 1 - 48.

2) "ENTER NAME"

   (a) Purpose - To reassign a new variable to the DAC.

   (b) Input Requested - Any interactive variable. Depressing the carriage return will retain the old assignment.

3) "SCALE FACTOR"

   (a) Purpose - To enter scale factor.

   (b) Input Requested - Any number.

Example -

```
OPTION
****  DACA
TO RETURN TO OPTIONS  HIT CR
ENTER DAC ARRAY NUM OR NAME
****  1
DACO( 1) = IOUT..(    1) /      1.0000
ENTER NAME
****  AYMAX
SCALE FACTOR
****  1.
ENTER DAC ARRAY NUM OR NAME
****
OPTION
```

ADCA (Alter ADC Array)

Identical to DAC routine with the exception that the interactive variable is assigned to an ADC not a DAC and the number must be 1 - 28

Example -

```
OPTION
****  ADCA
TO RETURN TO OPTIONS  HIT CR
ENTER ADC ARRAY NUM OR NAME
****  20
QUAN2.(    1) = ADCO(20) *      1.0000
ENTER NAME
****  SL1PI(2)
SCALE FACTOR
****  1.
ENTER ADC ARRAY NUM OR NAME
****
```

MULTI (Multiple Runs)

Purpose - To automatically execute a series of runs. Parameters (interactive variables) may be incremented from run to run by this routine. Parameters retain

their incremented value at the end of the multiple run.

Inputs Requested -

1) "NUMBER OF LOOPS, VARS"

   (a) Purpose - To specify the total number of runs to be made and the number of interactive variables to be incremented.

   (b) Input Requested - LOOPS, a number less than 100; VARS, a number less than 50.

2) "VAR"

   (a) Purpose - To specify the interactive variables to be incremented. The variables are incremented at the end of each run in the multi-loop. If a zero is entered, control is returned to OPTION.

   (b) Input Requested - Any interactive variable.

3) "LOOP, VAL, INC"

   (a) Purpose - To specify the run number, initial value, and increment per run.

   (b) Input Requested - A value can be specified for each run with a zero increment or a series can be setup by the input of an increment. The incrementing is halted at

each new LOOP input or when runs equal to the total number of LOOPS have completed.

Example -

```
OPTION
****  MULTI
NUM OF LOOPS,VARS
****  12 2
VAR
****  STR4
LOOP,VAL,INC
****  1 28. 28.
****  7 28. 28.
****
VAR
****  UIN
LOOP,VAL,INC
****  1 50. 0.
****  7 60.
****  7 60. 0.
****
OPTION
```

TEST (Test Run or Abend)

Purpose - To run the problem without real-time service or produce an abnormal termination, thus giving a program dump.

Input Requested

1) "ENTER: RTIME, NO RTIME, ABEND"

(a) Purpose - To indicate that a command is desired.

(b) Input Requested - One of three commands:

(1) No RTIME - This will remove the real-time calls.

(2) RTIME - This will replace the real-time calls.

(3) ABEND - Will produce a program dump.

Example -

```
OPTION
****  TEST
ENTER: RTIME,NO RTIME,ABEND
****  RTIME
```

MES (Send Message to Line Printer)

Purpose - To send a message to the line printer that will document analog programming changes (experimental or permanent), indicate the state of analog computer, or log simulation information.

Inputs Requested - A message that is less than 80 characters long per line.

Example -

```
OPTION
****  MES
TO RETURN TO OPTIONS HIT CR TWICE
****  THIS OPTION IS USEFUL FOR
****  DOCUMENTING SIMULATION RUNNING
****  AND KEEPING SIMULATION NOTES
****
```

TABLE (Tabular Output)

Purpose - To output data for a series of runs in a tabular form. Designed for use in the multi-run cases. This routine automatically is called whenever a multi-run case is in affect, unless it is deselected.

Input Requested - Up to nine interactive variables.

Example -

```
OPTION
****  TABLE
UNIT,MODE
****  T M
ENTER UP TO 9 NAMES
****  STR4 BETAMX BETDMX CUVRAT
****
```

TRACK (Track Real-Time Variables)

Purpose - To collect and output simulation data as a function of time.

Input Requested -

"TIME ON, OFF, STEP, VARIABLES"

1) TIME ON

(a) Purpose - To state the time in seconds that the routine will turn on.

(b) Input Requested - Any positive number.

2) TIME OFF

(a) Purpose - To state the time in seconds that the routine will turn off.

(b) Input Requested - Any positive number $\geq$ TIME ON.

3) TIME STEP

(a) Purpose - To state the time between samples. If this sample interval is too small, the program will automatically compensate for it.

(b) Input Requested - Any positive number.

4) VARIABLES

(a) Purpose - To enter the interactive variables to be tracked. Entering the word Retain will retain the previous variable list.

(b) Input Requested - Up to 50 variables.

Example -

```
OPTION
****  TRACK
UNIT,MODE
****  T A
ENTER TIME ON,OFF,STEP
****  .5 1.1 .1
TYPE RETAIN OR ENTER NEW ARRAY
****  PSIDT PHIDT PHI ZIMX(1) ZIMX(3)
****
```

```
 TIME   PSIDT.(    1)   PHIDT.(    1)  PHI...(     1)  ZIMX..(    1)  ZIMX..(    3)
  0.50   0.43077         0.77597E-02   -0.11728         0.29986E-01    0.10125
  0.60   0.35703         0.29683       -0.10414         0.29986E-01    0.10125
  0.70   0.28586         0.49151       -0.59047E-01     0.29986E-01    0.10125
  0.80   0.28740         0.32454       -0.16426E-01     0.29986E-01    0.10125
  0.90   0.30123         0.14344E-02   -0.12279E-03     0.29986E-01    0.10125
  1.00   0.28316        -0.14820       -0.90558E-02     0.29986E-01    0.10125
  1.10   0.29048        -0.38197       -0.30314E-01     0.29986E-01    0.10125
OPTION
```

<u>LA (List Array Values)</u>

Purpose - To output the values of variables which are array members.

Input Requested - Any Interactive Variable which is an array followed by the range of the array desired.

Example -

```
OPTION
****  LA
UNIT,MODE
****  T XEQ
ENTER  NAME,INDEX1,INDEX2
****  FRI 1 4
****  FSI 1 4
****  PRM 11 14
****  PARAM 11 14
****
FRI.....
   1==)  1073.          2==)  1073.          3==)  887.7          4==)  887.7
FSI.....
   1==) -10.51          2==)  10.51          3==) 0.0             4==) 0.0
PRM.....
  11==)  3832.         12==) 0.2400E 05     13==) 0.2431E 05     14==)  530.0
PARAM...
  11==)  3832.         12==) 0.2400E 05     13==) 0.2431E 05     14==)  530.0
```

REMOVE (Suspend Output)

Purpose - To cancel the execution of a selected Interactive Subroutine.

Input Requested - Any Interactive Subroutine name.

Example -

```
OPTION
****  REMOVE
WHAT
****  TRACK
```

The following routines have no inputs. Output is directed to the CRT.

T+D (Time + Date)

Purpose - To display the time and date.

Example -

```
OPTION
****  T+D
UNIT,MODE
****  T XEQ
JUNE      21   1974
TIME  14:30:40.67
```

STD (Standard Output)

Purpose - Select standard end of run data.

Example -

```
OPTION
**** STD
UNIT,MODE
**** T XEQ
 AXAV=   0.0   DECL TIME=   0.0   AVCUR=   0.0   BTDMAX=   0.0   BTMAX=   0.0   DELBT=   0.0
AYMAX=   0.000 PHIMAX=   0.0   RMAX=   0.0   LANE CHNG DEL=   0.0   DELPSI=   0.0   MAX STEER=   0.0
FTRQMAX=   0.0   RTRQMAX=   0.0
```

DUMP (Dump Data List)

Purpose - To display the value of each interactive variable at the time the dump is selected to execute.

Example -

```
OPTION
**** DUMP
UNIT,MODE
**** T XEQ

ABBTV.= 0.0         DEL1DT= 0.0          OIM...=  63.28       S3P...= -38.00
ABI...= 0.1962E-01  DEL2DA= 0.0          P.....= 0.0          S4P...= -38.00
AFA...=  1.000      DEL2DT= 0.0          PARAM.=  8.430       TBCR3.=  2.923
AIXBR.=  3928.      DEL3DA= 0.0          PBF...= 0.0          TBCR4.=  2.923
AIXP..=  169.8      DEL3DT= 0.0          PBR...= 0.0          TBSR3.=  1.038
AIXZBR=  177.5      DLIS..= -.8000       PDT...= -.3097E-03   TBSR4.= 0.9047
AIXZP.= -352.5      DLYTB.= -.2453E-54   PFI...=  1000.       TFRDAC= -.5380E 09
AIYBR.= 0.2322E 05  DSWMAX= 0.0          PHI...= 0.0          TF02..=  29.90
AIYP..=  169.8      DT....= 0.1000E-01   PHICGI= -.5630E 02   THE...= -.1215E-02
AIZBR.= 0.2944E 05  D1....= 0.0          PHIDAX= 0.0          THEDT.= 0.0
AKK1..=  1.000      D2....= -1.209       PHIDT.= 0.0          THEFNT= 0.7500
AKK2..=  1.000      D3....= 0.0          PHIFNT= -.3800       THEO..= -.1215E-02
ALII..= -.2262E 08  D4....= 0.1146E-68   PHII..= -.6405E-02   THERR.= 0.0
ALIQ..= -46.06      ETAL..= -.1133E-05   PHIMAX= 0.0          THRD..= 0.3333
AMI1..=  25.85      ETAX..= -.2176E-03   PHIO..= 0.0          THS1..= 0.1309E-01
AMI2..= -25.85      EXTAB.= -.1278E-56   PHIRD.= 0.0          THS2..= 0.1309E-01
AMUI..= 0.9657      E1....= 0.1156E 09   PHIRDA= 0.0          TIMBMP= 0.0
AM1I..=  5.018      E2....= -.4480E 06   PHIRR.= 0.0          TIMDEC= 0.0
AM2I..= -.2466      E3....= 0.1252E 06   PO....= 0.0          TIME..= 0.0
ANGNL.= 0.1180E 09  FBS1..= 0.0          PRM...=  8.430       TIME10= 0.0
ANGNLO= 0.8392E-04  FBS2..= 0.0          PSI...= 0.0          TIME25= 0.0
ANTI1.=  1.734      FBS3..= 0.0          PSIDT.= 0.0          TIMIN5= 0.0
ANTI2.=  1.734      FBS4..= 0.0          PSIFNT= -.2700       TMAX1.= 0.9942E 28
ANTI3.= -.1425      FCI...= 0.0          PSII..= -.1558E-02   TMAX2.= 0.1991E 06
ANTI4.= -.1425      FCIMAX=  892.9       PSIMAX= 0.0          TMAX3.= -.4879E-49
AP1...= 0.1381      FI....=  1.000       PSIO..= 0.0          TMP...= 0.0
AP2...= 0.1381      FOTM..= -1.218       PSIOUT= 0.0          TQBF..= 0.0
```

```
AP3...= -.1425     FRI...=  1047.      PSIRR.= 0.0         TQBR..= 0.0
AP4...= -.1425     FRIBR.=  1047.      PSI3S.= 0.0         TQFMAX= 0.0
ARPS1.=  56.79     FSI...= -19.70      PSI4S.= 0.0         TQRMAX= 0.0
ARPS2.=  56.97     FXL1..= 0.0         PS15..= 0.0         TRCR3.=  1.315
AR1...=  1.596     FXL2..= 0.0         PSR3..= 0.0         TRCR4.=  1.315
AR2...=  1.596     FXUI..= -1.302      PSR4..= 0.0         TRO2..=  30.90
AR3...= 0.0        FYUI..= -19.70      Q.....= 0.0         TRSR3.= 0.4669
AR4...= 0.0        G.....=  386.4      QDT...= 0.5060E-01  TRSR4.= 0.4069
AXAVE.= 0.0        GAMF..= 0.0         QO....= 0.0         TSO2..=  23.50
AXI...= 0.0        GAM1..= -31.19      QUAN1.= 0.0         TSTEP.= 0.1000E-01
AYMAX.= 0.1133E-05 GAM2..=  15.03      QUAN2.= 0.0         TWN7..= 0.3704E-01
A1....=  1.540     GAM3..=  15.03      QUAN3.= 0.0         U.....=  880.0
A12...= -1543.     GBI...= -.1949E-01  QUAN4.= 0.0         UDT...= -.8422E-01
A2....=  1545.     GETDL.= 0.0         R.....= 0.0         UGI...=  860.0
A2T...=  1900.     GI....= -.1082E-01  RDT...= -.2380E-05  UGIP..=  880.0
BAMI..= 0.2221E-02 GP1...= 0.2864E 06  RMAX..= 0.0         UI....=  880.0
BETAT.= 0.1558E-02 GP2...=  2202.      RMI...=  1011.      UIN...=  50.00
BETAMX= 0.0        GR1...=  2202.      RO....= 0.0         UO....=  880.0
BETDMX= 0.0        GR2...= 0.3811E 05  ROTM..= 0.0         UOUT..=  880.0
BETIBR= -.1962E-01 GV1...= 0.4480E 06  ROUT..= 0.0         U0I...= 0.8966
BETIP.= 0.6625E-03 GV2...= 0.1252E 06  RTAB..= -.8457E-53  U1I...= 0.6500
BMPN..= 0.0        IAX...= 0.5148E-84  RWZI..= 0.7219      U1P...= 0.0
BMPS..= 0.0        IDACK.= 0.0         RZF...=  24.50      U2P...= 0.0
BRKOFF=  1.020     IENDR.= -14.24      RZR...=  24.50      U3P...= 0.0
BRKON.= 0.5200     IERDAC= -14.24      SALTQ.= 0.0         U4P...= 0.0
BSLOPE= 0.5000E-01 IN....= -.2014E-02  SAMI..= 0.1272      V.....= 0.0
BTV...= 0.0        INA...= 0.2523E 09  SCR3..= 0.3551      VDT...= -.4844E-03
BTVDT.= -.4975E-06 IOR...= 0.8236E-83  SCR4..= 0.3095      VGI...= 0.0
CA20..= 0.6842E 07 IOUT..= 0.7892E-04  SFIN..= -100.0      VHTPNO=  6.000
CA23..=  3293.     IOUTA.= 0.2031E 38  SFOUT.=  1.000      VI....= 0.0
CIP...=  4105.     IPOT..= 0.1524E-81  SFXU..= -4.643      VO....= 0.0
CIVP..=  2046.     IPOTAD= 0.1524E-81  SFYU..= 0.0         VOUT..= 0.0
COSPSI=  1.000     IPRT..= 0.0         SINPSI= -.1558E-02  W.....= 0.0
CPSR3.=  1.000     ISW1..= 0.0         SLIPI.= 0.0         WCTH1.= -.7869
CPSR4.=  1.000     ISW7..= 0.0         SM....=  9.760      WCTH2.= -.9782
CURTBP= 0.0        ITMP..= 0.7892E-04  SN....= 0.0         WDT...=  18.51
CURVAV= 0.0        IVHTP.= 0.3089E-83  SNI...=  1.000      WI....= 0.0
CUVRAT= 0.0        JJTIME= 0.0         SNPHIU= -1.218      WO....= 0.0
CVI...=  50.00     JUMP..= 0.0         SNPSIU= 0.0         WSTH1.= 0.6163
DACO..= 0.7892E-04 MUP...= 0.8563      SNTHEU=  1166.      WSTH2.= 0.2056
DEL...= 0.0        NCAM..= 0.5432E 09  SPSR3.= 0.3551      X.....= 0.0
DELBET= 0.0        NCAS..= -.7418E-67  SPSR4.= 0.3095      XDT...=  880.0
DELFW1= 0.0        NFA...= 0.5148E-83  STR1..= 0.0         XO....= 0.0
DELFW2= 0.0        NTF...= 0.1030E-83  STR2..= 0.0         Y.....= 0.0
DELPHI= -.7662E 55 NTR...= 0.1030E-83  STR3..= 0.0         YDT...= 0.0
DELPSI= 0.0        N1....= 0.1519E-81  STR4..= 0.0         YO....= 0.0
DELSTR= 0.0        N2....= 0.6126E-82  STR5..=  223.4      Z.....= -23.84
DELTA.= 0.1118E 10 ONEOA.= -.6480E-03  STR6..=  223.4      ZDT...=  1.069
DELTHE= -.1079E-49 ONEOD.= 0.8947E-09  S1P...= -40.00      ZI....= -12.48
DEL1DA= 0.0        ONER..= -.5653E-09  S2P...= -40.00      ZIMX..= 0.7219
OPTION
```

DACL (DAC List)

Purpose - To list the DAC assignments and scale factors.

Example -

```
OPTION
****  DACL
UNIT,MODE
****  I XEQ
DACO( 1) = IOUT..(  1)/     1.0000
DACO( 2) = IOUT..(  2)/     1.0000
DACO( 3) = IOUT..(  3)/     1.0000
DACO( 4) = IOUT..(  4)/     1.0000
DACO( 5) = IOUT..(  5)/     1.0000
DACO( 6) = IOUT..(  6)/     1.0000
DACO( 7) = IOUT..(  7)/     1.0000
DACO( 8) = IOUT..(  8)/     1.0000
DACO( 9) = IOUT..(  9)/     1.0000
DACO(10) = IOUT..( 10)/     1.0000
DACO(11) = IOUT..( 11)/     1.0000
DACO(12) = IOUT..( 12)/     1.0000
DACO(13) = IOUT..( 13)/     1.0000
DACO(14) = IOUT..( 14)/     1.0000
DACO(15) = IOUT..( 15)/     1.0000
DACO(16) = IOUT..( 16)/     1.0000
DACO(17) = IOUT..( 17)/     1.0000
DACO(18) = IOUT..( 18)/     1.0000
DACO(19) = IOUT..( 19)/     1.0000
DACO(20) = IOUT..( 20)/     1.0000
DACO(21) = IOUT..( 32)/     1.0000
DACO(22) = IOUT..( 31)/     1.0000
DACO(23) = IOUT..( 23)/     1.0000
DACO(24) = IOUT..( 29)/     1.0000
DACO(25) = IOUT..( 25)/     1.0000
DACO(26) = IOUT..( 26)/     1.0000
DACO(27) = IOUT..( 27)/     1.0000
DACO(28) = IOUT..( 28)/     1.0000
DACO(29) = IOUT..( 24)/     1.0000
DACO(30) = IOUT..( 30)/     1.0000
DACO(31) = IOUT..( 22)/     1.0000
DACO(32) = IOUT..( 21)/     1.0000
DACO(33) = IOUT..( 33)/     1.0000
DACO(34) = IOUT..( 34)/     1.0000
DACO(35) = IOUT..( 35)/     1.0000
DACO(36) = IOUT..( 36)/     1.0000
DACO(37) = IOUT..( 37)/     1.0000
DACO(38) = ANTI1.(  1)/     10000.
DACO(39) = ANTI2.(  1)/     10000.
DACO(40) = ANTI3.(  1)/     10000.
DACO(41) = ANTI4.(  1)/     10000.
DACO(42) = ETAX..(  1)/     1.4000
DACO(43) = ETAL..(  1)/     1.4000
DACO(44) = ROUT..(  1)/     1.0000
DACO(45) = UOUT..(  1)/     1200.0
DACO(46) = VOUT..(  1)/     1200.0
DACO(47) = BTV...(  1)/     3.1400
DACO(48) = ONER..(  1)/    0.41700E-02
```

ADCL (ADC List)

Purpose - To list the ADC assignment and scale factors.

Example -

```
OPTION
****  ADCL
UNIT/MODE
****  T XEQ
DEL1DT(    1) = ADCO( 1)*     -100.00
DEL2DT(    1) = ADCO( 2)*     -100.00
DEL3DT(    1) = ADCO( 3)*     -100.00
DEL1DA(    1) = ADCO( 4)*      10.000
DEL2DA(    1) = ADCO( 5)*      10.000
DEL3DA(    1) = ADCO( 6)*      10.000
PHIRD.(    1) = ADCO( 7)*      1.0000
PHIRDA(    1) = ADCO( 8)*     0.25000
DELFW1(    1) = ADCO( 9)*     0.50000
DELFW2(    1) = ADCO(10)*     0.50000
U1P...(    1) = ADCO(11)*      2.0000
U2P...(    1) = ADCO(12)*      2.0000
U3P...(    1) = ADCO(13)*      2.0000
U4P...(    1) = ADCO(14)*      2.0000
S1P...(    1) = ADCO(15)*      1000.0
S2P...(    1) = ADCO(16)*      1000.0
S3P...(    1) = ADCO(17)*      1000.0
S4P...(    1) = ADCO(18)*      1000.0
QUAN1.(    1) = ADCO(19)*      1.0000
QUAN2.(    1) = ADCO(20)*      1.0000
QUAN3.(    1) = ADCO(21)*      1.0000
QUAN4.(    1) = ADCO(22)*      1.0000
ARPS1.(    1) = ADCO(23)*      100.00
ARPS2.(    1) = ADCO(24)*      100.00
WSTH1.(    1) = ADCO(25)*      1.0000
WCTH1.(    1) = ADCO(26)*      1.0000
WSTH2.(    1) = ADCO(27)*      1.0000
WCTH2.(    1) = ADCO(28)*      1.0000
OPTION
```

TERM (Terminate Program)

Purpose - To terminate program.

Example -

```
OPTION
****  TERM
JUNE       21  1974
TIME  17: 5:38.72
PROGRAM TERMINATED
```

If the OPTION cue detects an error or an error is forced by user, the active Subroutines can be determined by the input of a question mark (?).

Example -

```
OPTION
****
ERROR
****  ?
OPTION NOT FOUND
TO XEQ. PROGRAM           TYPE X
TO TERMINATE PROGRAM      TYPE TERM
FOR MULTIPLE RUNS         TYPE MULTI
FOR TEST RUN OR ABEND     TYPE TEST
TO ALTER DAC ARRAY        TYPE DACA
TO ALTER ADC ARRAY        TYPE ADCA
TO SET IC ONLY            TYPE IC
TO SEND MESSAGE TO LP     TYPE MES
FOR TIME AND DATE                  TYPE T+D
TO DUMP DATA LIST                  TYPE DUMP
FOR STANDARD OUTPUT                TYPE STD
TO TRACK REAL TIME VARIABLES       TYPE TRACK
FOR TABULAR OUTPUT                 TYPE TABLE
TO LIST DAC ARRAY                  TYPE DACL
TO LIST ADC ARRAY                  TYPE ADCL
```

APPENDIX E

SIMULATION DATA

1. PRESENTED HERE IS THE LISTING OF
THREE INPUT DATA DECKS

FOUR-WHEELED INDEPENDENT SUSPENSION -
VOLKSWAGEN CAMPMOBILE

```
076 CARNEW  VW VAN
DELFW1 DELFW2 PSII(1) PSII(2) PSII(3) PSII(4)
  DEL2DA PHIRDA
X Y SFXS SFYS
SFZS SNPHIS SNTHES SNPSIS
BETAI(1) BETAI(2) BETAI(3) BETAI(4)
BETIP(1) BETIP(2) BETIP(3) BETIP(4)
FRI(1) FRI(2) FRI(3) FRI(4)
FXUI(1) FXUI(2) FXUI(3) FXUI(4)
FSI(1) FSI(2) FSI(3) FSI(4)
FYUI(1) FYUI(2) FYUI(3) FYUI(4)
ETAX ETAL BTV R
P PHI

 PEL AXAVE TIMDEC AYMAX   SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)          MAIN  40
 PEL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)     MAIN  50
      BMPN BMPS AYMAX RMAX CUVRAT BETDMX                               MAIN  60
 STR4 BETAMX BETDMX CUVRAT AYMAX RMAX PHIMAX
 STR5 AYMAX DEL BETAMX DELPSI  UIN                                     MAIN  80
PHIMAX PHIDMX RMAX ZIMX(1) ZIMX(2) ZIMX(3) ZIMX(4) UIN  BRKOFF         MAIN  90
 PEL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)     MAIN 100
IOUT(01)  10000.                                                       MAIN 110
IOUT(02)  10.                                                          MAIN 120
IOUT(03)  10000.                                                       MAIN 130
IOUT(04)  10.                                                          MAIN 140
IOUT(05)  100.                                                         MAIN 150
IOUT(06)  10000.                                                       MAIN 160
IOUT(07)  100.                                                         MAIN 170
IOUT(08)  10000.
IOUT(09)  40000.                                                       MAIN 190
IOUT(10)  40000.                                                       MAIN 200
NOTUSED(1)  1.0                                                        MAIN 270
NOTUSED(1)  1.
IOUT(13)  100.                                                         MAIN 230
IOUT(14)  10000.                                                       MAIN 240
IOUT(15)  100.                                                         MAIN 250
IOUT(16)  10000.
IOUT(11)  10.                                                          MAIN 210
IOUT(18)  10.                                                          MAIN 280
NOTUSED(1)  1.0                                                        MAIN 290
IOUT(20)  10.                                                          MAIN 300
IOUT(21)  -20.
IOUT(22)  -20.
IOUT(23)  -20.
IOUT(24)  -20.
UGIP(1)   1500.                                                        MAIN 350
UGIP(2)   1500.                                                        MAIN 360
UGIP(3)   1500.                                                        MAIN 370
NOTUSED(1)  1.0                                                        MAIN 380
UGIP(4)   1500.                                                        MAIN 390
NOTUSED(1)  1.0                                                        MAIN 400
NOTUSED(1)  1.0                                                        MAIN 410
NOTUSED(1)  1.0                                                        MAIN 420
      IOUT(33)  -2.                                                    MAIN 430
      IOUT(34)  -2.                                                    MAIN 440
      IOUT(35)  -2.                                                    MAIN 450
      IOUT(36)  -2.                                                    MAIN 460
NOTUSED(1)  1.
ANTI1 10000.                                                           MAIN 480
```

```
ANTI2 10000.                                                          MAIN 490
ANTI3 10000.                                                          MAIN 500
ANTI4 10000.                                                          MAIN 510
ETAX 1.4                                                              MAIN 520
ETAL 1.4                                                              MAIN 530
R 1.0
U 1200.
VOUT 1200.                                                            MAIN 560
BTV .35
BTVDT .4
ENDNODAC                                                              MAIN 590
 DEL1DT -100.                                                         MAIN 600
DEL2DT   -100.
 DEL3DT -100.                                                         MAIN 620
 DEL1DA 10.                                                           MAIN 630
DEL2DA   10.
 DEL3DA 10.                                                           MAIN 650
 PHIRD -100.
PHIRDA 10.
DELFW1 -0.5                                                           MAIN 680
DELFW2 -0.5                                                           MAIN 690
U1P 2.                                                                MAIN 700
U2P 2.                                                                MAIN 710
U3P 2.                                                                MAIN 720
U4P 2.                                                                MAIN 730
S1P 2000.
S2P 2000.
S3P 2000.
S4P 2000.
QUAN1 1.                                                              MAIN 780
QUAN2 1.                                                              MAIN 790
QUAN3 1.                                                              MAIN 800
QUAN4 1.                                                              MAIN 810
ARPS3 100.                                                            MAIN 820
ARPS4 100.                                                            MAIN 830
RWZ1A -2.
RWZ2A -2.
RWZ3A -2.
RWZ4A -2.
ENDNOADC                                                              MAIN 880
                                                                      MAIN 890
INDXCN 4000
                                                                      MAIN 900
VEHICLE MODEL * VW CAMPMOBILE 1973
0.9509401 .06331873 .04225659 .04367653 .01231053 .0010975920.0
2.757724  -.1297874 -.03045931-.00649462-.00049561.0000235900.0
-.07321143-.03634039-.01556503-.00756957-.00160251-.000129640.0
-1.010893 .7207570  -.00401940.004555903-.00042666-.000099750.0
0.0       0.0       0.0       0.0       0.0       0.0       0.0
-.05058013-.06585461-.02369034-.00156075.000995467.0002581200.0
0.0       0.0             TABLE I * BRAKE TORQUE FUNCTION
1000.     8900.
99999.                                                                MAIN1020
0.0       0.0             TABLE II * BRAKE TORQUE FUNCTION
1000.     8900.
99999.                                                                MAIN1070
0.0        0.00      TABLE III- SIDE FORCE SHAPING FUNCTION
0.05       .01
0.1        .03
0.15       .07
```

```
0.2          .17
0.30         .35
0.4          .54
0.6          .81
0.8          .93
1.0          1.
99999.                                                        MAIN1180
0.0          .49          AERO COEFFICIENTS
.08727       0.52
.1745        0.56
.2618        0.59
.3491        0.6
.4363        0.58
.5236        0.56
.6109        0.52
.6981        0.46
.7854        0.41
.8727        .31
1.6          0.0
3.14         0.0
99999.
0.0          0.0
.08727       0.28
.1745        0.56
.2618        0.81
.3491        1.01
.4363        1.20
.5236        1.38
.6109        1.59
.6981        1.76
.7854        2.01
.8727        1.91
1.6          0.0
3.14         0.0
99999.
0.0          0.19
.08727       0.21
.1745        0.28
.2618        0.38
.3491        0.5
.4363        0.61
.5236        0.73
.6109        0.89
.6981        1.01
.7854        1.10
.8727        1.15
1.6          0.0
3.14         0.0
99999.
0.0          0.0
.08727       .052
.1745        .102
.2618        .141
.3491        .192
.4363        .227
.5236        .259
.6109        .299
.6981        .338
.7854        .382
.8727        .363
```

```
1.6         0.0
3.14        0.0
99999.
0.0         .052
.08727      .059
.1745       .065
.2618       .078
.3491       .091
.4363       .111
.5236       .126
.6109       .126
.6981       .128
.7854       .141
.8727       .123
1.6         0.0
3.14        0.0
99999.
0.0         0.0
.08727      .039
.1745       .083
.2618       .129
.3491       .167
.4363       .193
.5236       .202
.6109       .214
.6981       .221
.7854       .229
.8727       .196
1.6         0.0
3.14        0.0
99999.
0.0         0.0
.08727      0.0
.1745       0.0
.2618       0.0
.3491       0.0
.4363       0.0
.5236       0.0
.6109       0.0
.6981       0.0
.7854       0.0
.8727       0.0
1.6         0.0
3.14        0.0
99999.
-10.0       -20688.73    VW FRONT
-5.67       -1580.44     VW FRONT
-4.92       -908.44      VW FRONT
-3.74       -482.46      VW FRONT
0.          0.
.43         55.47        VW FRONT
10.         9003.42      VW FRONT
99999.
-10.0       -20688.73    VW FRONT
-5.67       -1580.44     VW FRONT
-4.92       -908.44      VW FRONT
-3.74       -482.46      VW FRONT
0.          0.
.43         55.47        VW FRONT
10.         9003.42      VW FRONT
```

```
99999.
-10.         -16375.09     VW REAR
-4.61        -1466.35      VW REAR
-3.54        -980.57       VW REAR
-1.57        -334.41       VW REAR
0.           0.            VW REAR
2.28         485.64        VW REAR
10.          8136.16       VW REAR
99999.
-10.         -16375.09     VW REAR
-4.61        -1466.35      VW REAR
-3.54        -980.57       VW REAR
-1.57        -334.41       VW REAR
0.           0.            VW REAR
2.28         485.64        VW REAR
10.          8136.16       VW REAR
99999.
0.0          0.0           WIND PROFILE DATA
0.           0.
0.           0.
0.           0.
99999.
066  40.       40.       40.       30.       40.       45.       50.
074  0.        0.        0.        30.       0.        0.        0.
076  5.        10.       10.       5.        5.5       4.        3.
114  62.       0.        62.       77.       0.        0.        0.
115  1.        0.        1.        1.        1.        0.        0.
116  .5        100.      .5        .5        .4        100.      100.
117  3.        0.        3.        0.        0.        0.        0.
118  3.        0.        3.        0.        0.        0.        0.
121  300.      200.      200.      0.        0.        0.        1000.
124  0.        0.        0.        0.        0.        2.5       1.
125  0.        0.        0.        0.        0.        0.        1.
126  0.        0.        0.        0.        0.        1.        1.
128  3.        1.        3.        4.        2.        5.        6.
192  1.        .1        .1        .1        .1        .1        .05
198  0.        0.        0.        12.       0.        0.        0.
199  0.        0.        0.        57.6      0.        0.        0.
201  0.        0.        0.        1000.     0.        0.        0.
277  0.        0.        0.        8.        0.        0.        0.
278  0.        0.        0.        0.        0.        0.        .52
279  0.        0.        0.        0.        0.        0.        1.02
123  0.        0.        0.        0.        0.        0.        0.
123  0.        0.        0.        0.        0.        0.        0.
123  0.        0.        0.        0.        0.        0.        0.
123  0.        0.        0.        0.        0.        0.        0.
123  0.        0.        0.        0.        0.        0.        0.
123  0.        0.        0.        0.        0.        0.        0.
123  0.        0.        0.        0.        0.        0.        0.
001 8.6
002 .507
003 .489
004 19.98
005 19.92
006 49.65
007 44.85
008 54.8
009 57.2
010 0.
011 7380.
```

```
012 24980.
013 25660.
014 1140.
015 696969.
016  0.                                                        MAIN1750
017 153000.
018 10.
019 129.
020 129.
021 213.
022 213.
023  0.                                                        MAIN1820
024 0.
025 33.
026 33.
027 56.
028 56.
029 0.0
030 0.
031 12.75
032 2000.
033 1.
034 2857.1
035 11.32
036 2845.5
037 .36
038 -5944.2
039 0.
040 0.
041 8592.
042 16.3
043
044
045
046
047 8.27
048 696969.
049 8.93
050 9.28
051 .3
052 5.375
053 0.
054 0.
055 .59
056 3.47
057 -3.47
058 -.0873
059 .0873
060  1.0                                                        MAIN2190
061 696969.
062 696969.
063                                                             MAIN2220
064                                                             MAIN2230
065                                                             MAIN2240
066  40.                                                        MAIN2250
067                                                             MAIN2260
068                                                             MAIN2270
069                                                             MAIN2280
070                                                             MAIN2290
071                                                             MAIN2300
```

```
072                                                     MAIN2310
073                                                     MAIN2320
074                                                     MAIN2330
075 .010                                                MAIN2340
 76  5.0                                                MAIN2350
077 1060.
078 1060.
079 1240.
080 1240.
081                                                     MAIN2400
082                                                     MAIN2410
083                                                     MAIN2420
084                                                     MAIN2430
085 -.000512
086 0.0
087 1.26
088 .000000114
089                                                     MAIN2480
090                                                     MAIN2490
091   0.0                                               MAIN2500
092 -1.54
093 -1.03
094                                                     MAIN2530
095                                                     MAIN2540
096                                                     MAIN2550
097                                                     MAIN2560
098                                                     MAIN2570
099                                                     MAIN2580
100                                                     MAIN2590
101                                                     MAIN2600
102                                                     MAIN2610
103                                                     MAIN2620
104                                                     MAIN2630
105                                                     MAIN2640
106                                                     MAIN2650
107   1.0                                               MAIN2660
108 .4                                                  MAIN2670
109 20.
110  4428.                                              MAIN2690
111  738.                                               MAIN2700
112  0.0                                                MAIN2710
113  1.                                                 MAIN2720
114  62.                                                MAIN2730
115  1.0                                                MAIN2740
116  0.5                                                MAIN2750
117  3.                                                 MAIN2760
118  3.                                                 MAIN2770
119 0.0
120 0.0
121  300.                                               MAIN2800
122                                                     MAIN2810
123                                                     MAIN2820
124                                                     MAIN2830
125                                                     MAIN2840
126                                                     MAIN2850
127                                                     MAIN2860
128  3.0                                                MAIN2870
129 0.                                                  MAIN2880
130 .038
131 .320
```

```
44000.
44000.
6.2
6.20
17.6
126.
5.68
.010
-.010
0.
0.0                                                                     MAIN3010
0.
0.
.0000001147
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
4216.0
179.13
1094.0
                                                                        MAIN3180
                                                                        MAIN3190
                                                                        MAIN3200
                                                                        MAIN3210
                                                                        MAIN3220
                                                                        MAIN3230
                                                                        MAIN3240
                                                                        MAIN3250
                                                                        MAIN3260
                                                                        MAIN3270
73.
75.
75.                                                                     MAIN3300
2.                                                                      MAIN3310
                                                                        MAIN3320
                                                                        MAIN3330
0.25                                                                    MAIN3340
                                                                        MAIN3350
                                                                        MAIN3360
                                                                        MAIN3370
4.
.14
.14
.19
.19
                                                                        MAIN3450
                                                                        MAIN3460
                                                                        MAIN3470
 0.0                                                                    MAIN3480
                                                                        MAIN3490
                                                                        MAIN3500
```

```
 1.                                   MAIN3510
                                      MAIN3520
                                      MAIN3530
                                      MAIN3540
0.
0.
                                      MAIN3570
                                      MAIN3580
 1.5                                  MAIN3590
                                      MAIN3600
1.24
-.000198
1.13
-.000119
.80
.82
.03
 0.                                   MAIN3680
 0.                                   MAIN3690
 0.0                                  MAIN3700
 0.                                   MAIN3710
 0.                                   MAIN3720
 0.                                   MAIN3730
 0.                                   MAIN3740
 0.                                   MAIN3750
 0.                                   MAIN3760
 0.                                   MAIN3770
0.
0.
0.0
0.0
 0.                                   MAIN3820
 0.                                   MAIN3830
 0.                                   MAIN3840
 0.                                   MAIN3850
 0.                                   MAIN3860
 0.                                   MAIN3870
 0.                                   MAIN3880
 0.                                   MAIN3890
400.
400.
1.0
1.9
1.9
1.0
1.0
-.0000372
-.000022
.0000020
-.0006785
0.0
1.45
.0000016971
-.002448
.002856
1.02
```

```
252 -.00156
253 .0011496
254 1.44
255 0.0
256 -.0010416
257 -.007008
258 -5.22
259 0.0
260 -.0006192
261 -.006048
262 -5.76
263 0.
264 0.
265 0.
266 .29
267 .03
268 0.
269 0.
270 0.
271 0.
272 .13
273 .03
274 0.
275 .0.0                                                    MAIN4340
276  0.0                                                    MAIN4350
277  0.                                                     MAIN4360
278  0.                                                     MAIN4370
279  0.                                                     MAIN4380
280  0.                                                     MAIN4390
281
282
283  0.                                                     MAIN4420
284 0.0
285 3.56
286  0.0                                                    MAIN4450
287 2.
288  0.                                                     MAIN4470
289  4.                                                     MAIN4480
290 1.0
291 -1441.2
292 16.44
293 3470.7
294 1.17
295 4139.5
304                                                         MAIN4550
./     ENDUP                                                MAIN4560
```

INDEPENDENT FRONT, SOLID REAR SUSPENSION - DODGE CORONET

```
091 CARNEW  DODGE71
  PSIDT PHIDT PHI ZIMX(1) ZIMX(3)

PFL AXAVE TIMDEC AYMAX SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)
 PFL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)      MAIN  50
      BMPN BMPS AYMAX RMAX CUVRAT BETDMX                                MAIN  60
STR4 BETAMX BETDMX CUVRAT AYMAX RMAX
 STR5 AYMAX DEL BETAMX DELPSI  UIN                                      MAIN  80
PHIMAX PHIDMX RMAX ZIMX(1) ZIMX(2) ZIMX(3) ZIMX(4) UIN  BRKOFF           MAIN  90
 PFL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)      MAIN 100
IOUT(01) 10000.                                                         MAIN 110
IOUT(02) 10.                                                            MAIN 120
IOUT(03) 10000.                                                         MAIN 130
IOUT(04) 10.                                                            MAIN 140
IOUT(05) 100.                                                           MAIN 150
IOUT(06) 10000.                                                         MAIN 160
IOUT(07) 100.                                                           MAIN 170
IOUT(08) 10000.
IOUT(09) 40000.                                                         MAIN 190
IOUT(10) 40000.                                                         MAIN 200
NOTUSED(1) 1.0                                                          MAIN 270
NOTUSED(1) 1.0
IOUT(13) 100.                                                           MAIN 230
IOUT(14) 10000.                                                         MAIN 240
IOUT(15) 100.                                                           MAIN 250
IOUT(16) 100.                                                           MAIN 260
IOUT(11) 10.                                                            MAIN 210
IOUT(18) 10.                                                            MAIN 280
NOTUSED(1) 1.0                                                          MAIN 290
IOUT(20) 10.                                                            MAIN 300
IOUT(21) -20.
IOUT(22) -20.
IOUT(23) -20.
IOUT(24) -20.
UGIP(1)  1500.                                                          MAIN 350
UGIP(2)  1500.                                                          MAIN 360
UGIP(3)  1500.                                                          MAIN 370
NOTUSED(1) 1.0                                                          MAIN 380
UGIP(4)  1500.                                                          MAIN 390
NOTUSED(1) 1.0                                                          MAIN 400
NOTUSED(1) 1.0                                                          MAIN 410
NOTUSED(1) 1.0                                                          MAIN 420
      IOUT(33) -2.                                                      MAIN 430
      IOUT(34) -2.                                                      MAIN 440
      IOUT(35) -2.                                                      MAIN 450
      IOUT(35) -2.                                                      MAIN 460
NOTUSED(    .0
ANTI1 10000.                                                            MAIN 480
ANTI2 10000.                                                            MAIN 490
ANTI3 10000.                                                            MAIN 500
ANTI4 10000.                                                            MAIN 510
ETAX 1.4                                                                MAIN 520
ETAL 1.4                                                                MAIN 530
R 1.0
U 1200.
VOUT 1200.
BTV .35
BTVDT .4
ENDNODAC                                                                MAIN 590
```

```
 DEL1DT -100.                                                                   MAIN 600
DEL2DT    -100.
 DEL3DT -100.                                                                   MAIN 620
 DEL1DA 10.                                                                     MAIN 630
DEL2DA    10.
 DEL3DA 10.                                                                     MAIN 650
PHIRD -1.
PHIRDA .25
DELFW1 -0.5                                                                     MAIN 680
DELFW2 -0.5                                                                     MAIN 690
U1P 2.                                                                          MAIN 700
U2P 2.                                                                          MAIN 710
U3P 2.                                                                          MAIN 720
U4P 2.                                                                          MAIN 730
S1P 1000.
S2P 1000.
S3P 1000.
S4P 1000.
QUAN1 1.                                                                        MAIN 780
QUAN2 1.                                                                        MAIN 790
QUAN3 1.                                                                        MAIN 800
QUAN4 1.                                                                        MAIN 810
ARPS3 100.                                                                      MAIN 820
ARPS4 100.                                                                      MAIN 830
RWZ1A -2.
RWZ2A -2.
RWZ3A -2.
RWZ4A -2.
ENDNOADC                                                                        MAIN 880
                                                                                MAIN 890
INDXCN 4000
                                                                                MAIN 900
VEHICLE MODEL * DODGE CORONET 1971
-0.38      .1061661  .1684393  .01604185 -.00579372-.00220835 0.0
0.75       0.0       0.0       0.0       0.0       0.0        0.0               MAIN9110
-0.27      -.2416662 -.00944941.01291661 -.00089631-.00125    0.0
0.0        0.0       0.0       0.0       0.0       0.0        0.0
0.0        0.0       0.0       0.0       0.0       0.0        0.0               MAIN9140
0.0        0.0       0.0       0.0       0.0       0.0        0.0               MAIN9150
0.         0.              TABLE I - FRONT BRAKE TORQUE FUNCTION
1000.      20640.
99999.                                                                          MAIN9190
0.         0.              TABLE II - REAR BRAKE TORQUE FUNCTION
1000.      20640.
99999.                                                                          MAIN9230
0.          0.        TABLE III- SIDE FORCE SHAPING FUNCTION
.05         .01
.1          .03
.15         .07
.2          .17
.3          .35
.4          .54
.6          .81
.8          .93
1.          1.
99999.                                                                          MAIN9410
0.0        0.0            AERO COEFFICIENTS
99999.
0.0        0.0
99999.
```

```
0.0          0.0
99999.
0.0          0.0
99999.
0.0          0.0
99999.
0.0          0.0
99999.
0.0          0.0
99999.
-10.0         -1688.                   FRONT SPRING DATA
-2.4          -252.
0.0           0.0
2.1           221.
10.0          4866.
99999.
-10.0         -1688.                   FRONT SPRING DATA
-2.4          -252.
0.0           0.0
2.1           221.
10.0          4866.
99999.
-10.0         -2342.                   REAR SPRING DATA
-4.4          -528.
0.0           0.0
3.6           432.
10.0          5962.
99999.
-10.0         -2342.                   REAR SPRING DATA
-4.4          -528.
0.0           0.0
3.6           432.
10.0          5962.
99999.
0.0          0.0             WIND TUNNEL DATA
99999.
066  40.         40.        40.        30.        40.        45.        50.
074  0.          0.         0.         30.        0.         0.         0.
076  5.          10.        10.        5.         5.5        4.         3.
112                                               55.
114  62.         0.         82.        139.       0.         0.         0.
115  1.          0.         1.         1.         1.         0.         0.
116  .5          100.       .5         .5         .4         100.       100.
117  3.          0.         3.         0.         0.         0.         0.
118  3.          0.         3.         0.         0.         0.         0.
121  300.        200.       200.       0.         0.         0.         1000.
124  0.          0.         0.         0.         0.         2.         1.
125  0.          0.         0.         0.         0.         0.         1.
126  0.          0.         0.         0.         0.         1.         1.
128  3.          1.         3.         4.         2.         5.         6.
192  1.          .1         .1         .1         .1         .1         .05
198  0.          0.         0.         12.        0.         0.         0.
199  0.          0.         0.         57.6       0.         0.         0.
201  0.          0.         0.         1000.      0.         0.         0.
277  0.          0.         0.         8.         0.         0.         0.
278  0.          0.         0.         0.         0.         0.         .52
279  0.          0.         0.         0.         0.         0.         1.02
123  0.          0.         0.         0.         0.         0.         0.
123  0.          0.         0.         0.         0.         0.         0.
123  0.          0.         0.         0.         0.         0.         0.
```

```
123  0.       0.       0.       0.       0.       0.       0.
123  0.       0.       0.       0.       0.       0.       0.
123  0.       0.       0.       0.       0.       0.       0.
001  8.43
002  0.51
003  0.82
004  11.3
005  11.3
006  49.3
007  68.7
008  59.8
009  61.8
010  47.0
011  3758.
012  23047.
013  23327.
014  530.
015  550.
016  0.                                                    MAIN9730
017  40400.
018 10.
019 105.0
020 105.0
021 120.0
022 120.0
023  0.                                                    MAIN9800
024  -5100.
025 40.0
026 40.0
027 38.0
028 38.0
029 0.
030  0.020
031  13.2
032 1000.
033   0.75                                                 MAIN9900
034  2701.
035  10.14
036  2533.
037  1.30
038  4591.
039 0.0
040 0.0
041  8000.
042  14.2
043
044
045
046
047  6.4
 48  550.
049  9.4
050  9.4
051  0.7
052  2.71
053 0.0
054 0.0
055 -0.66
056  4.59
057 -4.59
```

```
-.1309
 .1309
 1.0
0.0
0.0
                                                        MAIN0200
                                                        MAIN0210
                                                        MAIN0220
 40.
                                                        MAIN0240
                                                        MAIN0250
                                                        MAIN0260
                                                        MAIN0270
                                                        MAIN0290
                                                        MAIN0300
                                                        MAIN0310
.005
 5.0
 1450.
 1450.
 1450.
 1450.
 -.00033
 0.0
 1.228
 .0000000759
                                                        MAIN0460
                                                        MAIN0470
                                                        MAIN0480
  0.0
 -0.8
-.68
                                                        MAIN0510
                                                        MAIN0520
                                                        MAIN0530
                                                        MAIN0540
                                                        MAIN0550
                                                        MAIN0560
                                                        MAIN0570
                                                        MAIN0580
                                                        MAIN0590
                                                        MAIN0600
                                                        MAIN0610
                                                        MAIN0620
                                                        MAIN0630
  1.0                                                   MAIN0640
0.5
15.
0.0
0.0
 0.0
 1.                                                     MAIN0700
25.
 1.0
 0.5
 3.
```

```
 3.
                                            MAIN0760
                                            MAIN0770
 300.
                                            MAIN0790
                                            MAIN0800
                                            MAIN0810
                                            MAIN0820
                                            MAIN0830
                                            MAIN0840
 3.0
0.                                          MAIN0860
 0.06
 16.0
 55900.
 55900.
 6.62
 6.62
 11.0
 54.
 5.20
 0.45
-0.45
 0.                                         MAIN0980
88.
.03
.04
.001
.10
.010
.001
.006
.001
.001
.0001
.0001
.0003
.0004
500.
                                            MAIN1140
                                            MAIN1150
                                            MAIN1160
                                            MAIN1170
                                            MAIN1180
                                            MAIN1190
                                            MAIN1200
                                            MAIN1210
                                            MAIN1220
                                            MAIN1230
                                            MAIN1240
                                            MAIN1250
 73.
 73.
 73.
2.                                          MAIN1290
                                            MAIN1300
                                            MAIN1310
0.25                                        MAIN1320
                                            MAIN1330
                                            MAIN1340
```

```
                                            MAIN1350
4.0
 0.17
 0.17
 0.17
 0.17
                                            MAIN1430
                                            MAIN1440
                                            MAIN1450
 0.0
                                            MAIN1470
                                            MAIN1480
 1.                                         MAIN1490
                                            MAIN1500
                                            MAIN1510
                                            MAIN1520
 0.
 0.
 1.5                                        MAIN1570
 0.94
 -.00008
 0.94
 -.00008
 0.65
 0.65
.03
 0.
 0.
 0.0                                        MAIN1680
 0.
 0.
 0.                                         MAIN1710
 0.
 0.
 0.
 0.
 0.
 0.
 0.
 0.
0.0
 0.
 0.
 0.
 0.
 0.
 0.
 0.
  400.
  400.
1.0
```

238	1.	
239	1.	
240	.67	
241	.67	
242	-.0000393	
243	-.0000332	
244	.00000175	
245	-.00033	
246	0.0	
247	1.228	
248	.0000000759	
249	-.00318	
250	.00349	
251	1.404	
252	-.00318	
253	.00349	
254	1.404	
255	0.0	
256	-.0015	
257	-.005244	
258	-5.592	
259	0.0	
260	-.0015	
261	-.005244	
262	-5.592	
263	-0.13	
264	-.03	
265	.0	
266	0.15	
267	.015	
268	.0	
269	0.089	
270	.01	
271	.0	
272	0.0	
273	.0	
274	.0	
275	0.0	
276	0.0	
277	0.	MAIN2340
278	0.	MAIN2350
279	0.	MAIN2360
280	0.	MAIN2370
281		
282		
283	0.	MAIN240C
284	2.7	
285	3.9	
286	0.0	
287	1.	
288	0.	MAIN2450
289	4.	
290	0.75	MAIN2470
291	2701.	
292	10.14	
293	2533.	
294	1.30	
295	4591.	
001	8.82	
004	10.9	

```
005  10.8
006  50.5
007  67.5
011  3832.
012  24003.
013  24311.
092  -1.1
093 -1.08
304                                                    MAIN2660
./     ENDUP
```

SOLID FRONT AND REAR SUSPENSION WITH
DUAL REAR TIRES - WINNEBAGO MOTOR HOME

```
076 CARNEW  MOTOR
FRI(1) FRI(2) F5ROD F3RID F4RID F6ROD ETAX ETAL
FSI(1) FSI(2) FSI5 FSI3 FSI4 FSI6 PHI
FYUI(1) FYUI(2) FYU5 FYUI(3) FYUI(4) FYU6 P
FXUI(1) FXUI(2) FXU5 FXUI(3) FXUI(4) FXU6 R
SLIPI(1) SLIPI(2) S5OD S3ID S4ID S6OD BTV
BETAI(1) BETAI(2) BETAI(3) BETAI(4)  CF5OD CF3ID X
AMUI(1) AMUI(2) AMUI5 AMUI3 AMUI4 AMUI6 Y
                                                                         MAIN  30
 PFL AXAVE TIMDEC AYMAX   SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)            MAIN  40
 PFL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)       MAIN  50
     BMPN BMPS AYMAX RMAX CUVRAT BETDMX                                  MAIN  60
 STR4 BETAMX BETDMX CUVRAT AYMAX RMAX PHIMAX
 STR5 AYMAX DEL BETAMX DELPSI  UIN                                       MAIN  80
PHIMAX PHIDMX RMAX ZIMX(1) ZIMX(2) ZIMX(3) ZIMX(4) UIN  BRKOFF            MAIN  90
 PFL AXAVE AYMAX BETDMX CUVRAT SLIPI(1) SLIPI(2) SLIPI(3) SLIPI(4)       MAIN 100
IOUT(01) 10000.                                                          MAIN 110
IOUT(02) 10.                                                             MAIN 120
IOUT(03) 10000.                                                          MAIN 130
IOUT(04) 10.                                                             MAIN 140
IOUT(05) 100.                                                            MAIN 150
IOUT(06) 10000.                                                          MAIN 160
IOUT(07) 100.                                                            MAIN 170
IOUT(08) 100.
IOUT(09) 40000.                                                          MAIN 190
IOUT(10) 40000.                                                          MAIN 200
NOTUSED(1) 1.0
NOTUSED(1) 1.0
IOUT(13) 100.                                                            MAIN 230
IOUT(14) 10000.                                                          MAIN 240
IOUT(15) 100.                                                            MAIN 250
IOUT(16) 100.                                                            MAIN 260
IOUT(11) 10.                                                             MAIN 210
IOUT(18) 10.                                                             MAIN 280
NOTUSED(1) 1.0                                                           MAIN 290
IOUT(20) 10.                                                             MAIN 300
IOUT(21) -20.
IOUT(22) -20.
IOUT(23) -20.
IOUT(24) -20.
UGIP(1)  1500.                                                           MAIN 350
UGIP(2)  1500.                                                           MAIN 360
UGIP(3)  1500.                                                           MAIN 370
NOTUSED(1) 1.0                                                           MAIN 380
UGIP(4)  1500.                                                           MAIN 390
NOTUSED(1) 1.0                                                           MAIN 400
NOTUSED(1) 1.0                                                           MAIN 410
NOTUSED(1) 1.0                                                           MAIN 420
     IOUT(33) -2.                                                        MAIN 430
     IOUT(34) -2.                                                        MAIN 440
     IOUT(35) -2.                                                        MAIN 450
     IOUT(36) -2.                                                        MAIN 460
NOTUSED(1) 1.0
ANTI1 10000.                                                             MAIN 480
ANTI2 10000.                                                             MAIN 490
ANTI3 10000.                                                             MAIN 500
ANTI4 10000.                                                             MAIN 510
ETAX 1.4                                                                 MAIN 520
ETAL 1.4                                                                 MAIN 530
```

```
R 1.0
U 1200.
VOUT 1200.                                                          MAIN 560
BTV .35
BTVDT .4
ENDNODAC                                                            MAIN 590
 DEL1DT -100.                                                       MAIN 600
DEL2DT   -1.
 DEL3DT -100.                                                       MAIN 620
 DEL1DA 10.                                                         MAIN 630
DEL2DA   .25
 DEL3DA 10.                                                         MAIN 650
PHIRD -1.
PHIRDA .25
DELFW1 -0.5                                                         MAIN 680
DELFW2 -0.5                                                         MAIN 690
U1P 2.                                                              MAIN 700
U2P 2.                                                              MAIN 710
U3P 2.                                                              MAIN 720
U4P 2.                                                              MAIN 730
S1P 4000.
S2P 4000.
S3P 4000.
S4P 4000.
QUAN1 1.                                                            MAIN 780
QUAN2 1.                                                            MAIN 790
QUAN3 1.                                                            MAIN 800
QUAN4 1.                                                            MAIN 810
ARPS3 100.                                                          MAIN 820
ARPS4 100.                                                          MAIN 830
RWZ1A -2.
RWZ2A -2.
RWZ3A -2.
RWZ4A -2.
ENDNOADC                                                            MAIN 880
                                                                    MAIN 890
INDXCN 4000
                                                                    MAIN 900
VEHICLE MODEL * WINNABAGO MOTOR HOME TYPE A (DODGE RM 400/158.5" WB)
0.0      0.0      0.0      0.0      0.0      0.0
0.0      0.0      0.0      0.0      0.0      0.0
0.0      0.0      0.0      0.0      0.0      0.0
0.0      0.0      0.0      0.0      0.0      0.0
0.0      0.0      0.0      0.0      0.0      0.0
0.0      0.0      0.0      0.0      0.0      0.0
0.0      0.0      TABLE I * BRAKE TORQUE FUNCTION
80.      0.0
1000.    53000.
1600.    [illegible]
99999.
0.0      0.0      TABLE II * BRAKE TORQUE FUNCTION
80.      0.0
1000.    53000.
1600.    75000.
99999.
0.        0.      TABLE III- SIDE FORCE SHAPING FUNCTION
.05       .01
.1        .03
.15       .07
.2        .17
```

```
.3          .35
.4          .54
.6          .81
.8          .93
1.          1.
99999.                                                          MAIN1180
0.0         .78        AERO COEFFICIENTS
.08727      .79
.1745       .83
.2618       .90
.3491       .94
.4364       .94
1.6         0.0
3.14        0.0
99999.
0.0         0.0
.08727      .33
.1745       .58
.2618       .90
.3491       1.33
.4364       1.82
1.6         0.0
3.14        0.0
99999.
0.0         .15
.08727      .29
.1745       .45
.2618       .55
.3491       .84
.4364       1.11
1.6         0.0
3.14        0.0
99999.
0.0         0.0
.08727      .12
.1745       .20
.2618       .34
.3491       .48
.4364       .64
1.6         0.0
3.14        0.0
99999.
0.0         .19
.08727      .25
.1745       .29
.2618       .33
.3491       .35
.4364       .37
1.6         0.0
3.14        0.0
99999.
0.0         0.0
.08727      -.12
.1745       -.15
.2618       -.15
.3491       -.15
.4364       -.17
1.6         0.0
3.14        0.0
99999.
```

```
0.0          0.0
.08727       0.0
.1745        0.0
.2618        0.0
.3491        0.0
.4364        0.0
1.6          0.0
3.14         0.0
99999.
-10.0       -6579.    FRONT SPRING DATA
-2.3        -1035.0
0.0         0.0
3.1         1395.0
10.0        10089.
99999.
-10.0       -6579.    FRONT SPRING DATA
-2.3        -1035.0
0.0         0.0
3.1         1395.0
10.0        10089.
99999.
-10.0       -10366.5  REAR SPRING DATA
-3.9        -3412.5
0.0         0.0
2.7         2362.5
10.0        15137.5
99999.
-10.0       -10366.5  REAR SPRING DATA
-3.9        -3412.5
0.0         0.0
2.7         2362.5
10.0        15137.5
99999.
1128.        0.0          WIND PROFILE DATA
1140.        1056.
1248.        1056.
1260.        0.0
99999.
066  40.        40.       40.       30.       40.       45.       50.
074  0.         0.        0.        30.       0.        0.        0.
076  5.         10.       10.       5.        5.5       4.        3.
114  62.        0.        62.       77.       0.        0.        0.
115  1.         0.        1.        1.        1.        0.        0.
116  .5         100.      .5        .5        .4        100.      100.
117  3.         0.        3.        0.        0.        0.        0.
118  3.         0.        3.        0.        0.        0.        0.
121  300.       200.      200.      0.        0.        0.        1000.
124  0.         0.        0.        0.        0.        2.5       1.
125  0.         0.        0.        0.        0.        0.        1.
126  0.         0.        0.        0.        0.        1.        1.
128  3.         1.        3.        4.        2.        5.        6.
192  1.         .1        .1        .1        .1        .1        .05
198  0.         0.        0.        12.       0.        0.        0.
199  0.         0.        0.        57.6      0.        0.        0.
201  0.         0.        0.        1000.     0.        0.        0.
277  0.         0.        0.        8.        0.        0.        0.
278  0.         0.        0.        0.        0.        0.        .52
279  0.         0.        0.        0.        0.        0.        1.02
123  0.         0.        0.        0.        0.        0.        0.
123  0.         0.        0.        0.        0.        0.        0.
```

```
123  0.          0.          0.          0.          0.          0.          0.
123  0.          0.          0.          0.          0.          0.          0.
123  0.          0.          0.          0.          0.          0.          0.
123  0.          0.          0.          0.          0.          0.          0.
123  0.          0.          0.          0.          0.          0.          0.
001 24.609
002 1.721
003 2.888
004 36.30
005 36.19
006 99.41
007 59.09
008 66.15
009 66.12
010 41.24
011 40300.
012 219100.
013 216500.
014 7100.
015 2400.
016  0.                                                                       MAIN1750
017 153000.
018 10.
019 450.
020 450.
021 875.
022 875.
023  0.                                                                       MAIN1820
024 153000.
025 100.
026 100.
027 150.
028 150.
029 0.0
030 -.01
031 16.87
032 4000.
033 1.0
034 635.2
035 11.98
036 5447.9
037 1.89
038 6306.2
039 56.62
040 75.62
041 8000.
042 17.5
043
044
045
046
047 27.0
048 1500.
049 21.3
050 48.0
051 1.30
052 4.56
053 31.0
054 .07
055 1.31
```

```
056 6.08
057 -6.08
058 -.12217
059 .12217
060  1.0
061 0.                                                   MAIN2190
062 0.
063
064                                                      MAIN2220
065                                                      MAIN2230
066  40.                                                 MAIN2240
067                                                      MAIN2250
068                                                      MAIN2260
069                                                      MAIN2270
070                                                      MAIN2280
071                                                      MAIN2290
072                                                      MAIN2300
073                                                      MAIN2310
074                                                      MAIN2320
075 .010                                                 MAIN2330
 76  5.0                                                 MAIN2340
077 3040.                                                MAIN2350
078 3040.
079 3040.
080 3040.
081
082                                                      MAIN2400
083                                                      MAIN2410
084                                                      MAIN2420
085 -.000236                                             MAIN2430
086 0.0
087 1.32
088 .0000000297
089
090                                                      MAIN2480
091   0.0                                                MAIN2490
092 0.0                                                  MAIN2500
093 0.0
094
095                                                      MAIN2530
096                                                      MAIN2540
097                                                      MAIN2550
098                                                      MAIN2560
099                                                      MAIN2570
100                                                      MAIN2580
101                                                      MAIN2590
102                                                      MAIN2600
103                                                      MAIN2610
104                                                      MAIN2620
105                                                      MAIN2630
106                                                      MAIN2640
107   1.0                                                MAIN2650
108 .4                                                   MAIN2660
109 20.                                                  MAIN2670
110  4428.
111  738.                                                MAIN2690
112  0.0                                                 MAIN2700
113  1.                                                  MAIN2710
114  62.                                                 MAIN2720
115  1.0                                                 MAIN2730
                                                         MAIN2740
```

```
116  0.5                                                        MAIN2750
117  3.                                                         MAIN2760
118  3.                                                         MAIN2770
119 0.0
120 0.0
121  300.                                                       MAIN2800
122                                                             MAIN2810
123                                                             MAIN2820
124                                                             MAIN2830
125                                                             MAIN2840
126                                                             MAIN2850
127                                                             MAIN2860
128  3.0                                                        MAIN2870
129 0.                                                          MAIN2880
130 .078
131 .279
132 150000.
133 150000.
134 8.02
135 8.02
136 11.
137 120.
138 7.50
139 .009
140 -.009
141  0.                                                         MAIN3000
142 0.0                                                         MAIN3010
143 0.
144 0.
145 .0000001147
146 0.0
147 0.0                                                         MAIN3060
148 0.0                                                         MAIN3070
149 0.0                                                         MAIN3080
150 0.0                                                         MAIN3090
151 0.0                                                         MAIN3100
152 0.0                                                         MAIN3110
153 0.0                                                         MAIN3120
154 0.0                                                         MAIN3130
155 0.0                                                         MAIN3140
156 9100.
157 294.
158 1094.
159                                                             MAIN3180
160                                                             MAIN3190
161                                                             MAIN3200
162                                                             MAIN3210
163                                                             MAIN3220
164                                                             MAIN3230
165                                                             MAIN3240
166                                                             MAIN3250
167                                                             MAIN3260
168                                                             MAIN3270
169 73.
170 75.
171 75.                                                         MAIN3300
172 2.                                                          MAIN3310
173                                                             MAIN3320
174                                                             MAIN3330
175 0.25                                                        MAIN3340
```

```
176                                   MAIN3350
177                                   MAIN3360
178                                   MAIN3370
179
180 4.
181
182 .20
183 .20
184 .20
185 .20
186                                   MAIN3450
187                                   MAIN3460
188                                   MAIN3470
189  0.0                              MAIN3480
190                                   MAIN3490
191                                   MAIN3500
192  1.                               MAIN3510
193                                   MAIN3520
194                                   MAIN3530
195                                   MAIN3540
196 -.0018
197 .0018
198                                   MAIN3570
199                                   MAIN3580
200  1.5                              MAIN3590
201                                   MAIN3600
202 1.04
203 -.0000758
204 1.04
205 -.0000758
206 .72
207 .72
208 .03
209  0.                               MAIN3680
210  0.                               MAIN3690
211  0.0                              MAIN3700
212  0.                               MAIN3710
213  0.                               MAIN3720
214  0.                               MAIN3730
215  0.                               MAIN3740
216  0.                               MAIN3750
217  0.                               MAIN3760
218  0.                               MAIN3770
219 .0349
220 -0.0349
221 .0698
222 .0698
223  0.                               MAIN3820
224  0.                               MAIN3830
225  0.                               MAIN3840
226  0.                               MAIN3850
227  0.                               MAIN3860
228  0.                               MAIN3870
229  0.                               MAIN3880
230  0.                               MAIN3890
231 600.
232 600.
233 0.
234
235
```

```
1.13
1.13
1.0
1.0
-.000020
-.000020
.0000015
-.000236
0.0
1.32
.0000000297
-.00157
.00148
1.608
-.00157
.00148
1.608
0.0
-.000624
.00240
-9.132
0.0
-.000624
.00240
-9.132
0.
0.
0.
0.
0.
0.
0.
0.
0.
0.
0.
0.
 0.0                                                                   MAIN4340
 0.0                                                                   MAIN4350
 0.                                                                    MAIN4360
 0.                                                                    MAIN4370
 0.                                                                    MAIN4380
 0.                                                                    MAIN4390
 0.                                                                    MAIN4420
0.
0.
 0.0                                                                   MAIN4450
0.
1.
 4.                                                                    MAIN4480
1.0
635.2
11.98
5447.9
1.89
6306.2
```

4

```
304                                                          MAIN4550
./      ENDUP                                                MAIN4560
```

2. PRESENTED HERE ARE THE WHEEL SPRING AND SHOCK ABSORBER CHARACTERISTICS

WHEEL SPRING CHARACTERISTICS

The entries in this table are the values of the slopes versus suspension displacement for the no-load (curb weight) vehicle configuration. The units of the entries are lbs/in and inches.

Vehicle	Spring Force Effective at the Wheel for the Independent Front Suspension and at the Spring Location for the Solid Front Axle	Spring Force Effective at the Wheel for the Independent Rear Suspension and at the Spring Location for the Solid Rear Axle
VW Campmobile	935 for $\delta \geq 0.43$	991 for $\delta \geq 2.28$
	129 for $-3.74 < \delta < 0.43$	213 for $-1.57 < \delta < 2.28$
	361 for $-4.92 < \delta \leq -3.74$	328 for $-3.54 < \delta \leq -1.57$
	896 for $-5.67 < \delta \leq -4.92$	454 for $-4.61 < \delta \leq -3.54$
	4413 for $\delta \leq -5.67$	2766 for $\delta \leq -4.61$
Dodge Coronet	558 for $\delta > 2.1$	864 for $\zeta \geq 3.6$
	105 for $-2.4 < \delta < 2.1$	120 for $-4.4 < \zeta < 3.6$
	189 for $\delta < -2.4$	324 for $\zeta \leq -4.4$
Winnegabo Motor Home	1260 for $\zeta \geq 3.1$	1750 for $\zeta \geq 2.7$
	450 for $-2.3 < \zeta < 3.1$	875 for $-3.9 < \zeta < 2.7$
	720 for $\zeta \leq -2.3$	1140 for $\zeta \leq -3.9$

SHOCK ABSORBER CHARACTERISTICS

The entries in this table are the values of the slopes versus suspension velocity. The units of the entries are lbs/(in/sec) and in/sec.

Vehicle	Viscous Damping Force Effective at the Wheel for the Independent Front Suspension and at the Spring Location for the Solid Front Axle	Viscous Damping Force Effective at the Wheel for the Independent Rear Suspension and at the Spring Location for the Solid Rear Axle
VW Campmobile	5.14 for $\dot{\delta} \geq 11.8$	11.24 for $\dot{\delta} > 9.8$
	17.63 for $3.0 \leq \dot{\delta} < 11.8$	35.60 for $4.2 \leq \dot{\delta} < 9.8$
	9.55 for $0 \leq \dot{\delta} < 3.0$	22.86 for $0 \leq \dot{\delta} < 4.2$
	4.06 for $-15.0 \leq \dot{\delta} < 0$	7.93 for $-10.6 \leq \dot{\delta} < 0$
	2.09 for $\dot{\delta} < -15.0$	2.49 for $\dot{\delta} < -10.6$
Dodge Coronet	9.36 for $\dot{\delta} \geq 0$	6.63 for $\dot{\zeta} \geq 0$
	4.33 for $\dot{\delta} < 0$	8.32 for $-7.2 < \dot{\zeta} < 0$
		1.50 for $\dot{\zeta} < -7.2$
Winnebago Motor Home	9.6 for $\dot{\zeta} \geq 6.0$	5.34 for $\dot{\zeta} \geq 4.4$
	25.02 for $1.4 \leq \dot{\zeta} < 6.0$	13.76 for $0.8 \leq \dot{\zeta} < 4.4$
	118.15 for $0 \leq \dot{\zeta} < 1.4$	73.50 for $0 \leq \dot{\zeta} < 0.8$
	12.84 for $-8.4 \leq \dot{\zeta} < 0$	3.47 for $-9.8 \leq \dot{\zeta} < 0$
	3.10 for $\dot{\zeta} < -8.4$	8.49 for $\dot{\zeta} < -9.8$

3. PRESENTED HERE ARE THE CAMBER, CASTER, AND TOE DATA

CAMBER, CASTER, AND TOE DATA

To obtain these data, the wheel was moved from the full rebound position to compression bump stop. In order to use these data in calculations, one must know the values of camber, caster, and toe at a reference value of suspension displacement which depends upon vehicle loading. The units of the entries are inches and degrees. The data presented here were measured with reference to a no-load (curb weight) vehicle configuration.

Vehicle	Displacement	Camber	Caster	Toe
VW Campmobile (right front wheel) (static displacement = 0.0)	0.5	1.00	2.67	-0.10
	0.0	0.95	2.77	-0.07
	-1.0	0.90	2.85	-0.05
	-2.0	0.80	2.95	-0.02
	-3.0	0.70	3.00	0.00
	-4.0	0.60	3.05	0.03
	-5.0	0.50	3.08	0.07
	-5.5	0.35	3.05	0.10
VW Campmobile (right rear wheel) (static displacement = 0.0)	2.5	0.80	0.00	-0.333
	2.0	0.45	0.00	-0.258
	1.0	-3.00	0.00	-0.146
	0.0	-1.00	0.00	-0.050
	-1.0	-1.75	0.00	0.000
	-2.0	-2.50	0.00	0.000
	-3.0	-3.35	0.00	-0.004
	-4.0	-4.25	0.00	-0.075
	-4.5	-4.75	0.00	-0.162

CAMBER, CASTER, AND TOE DATA (Cont'd)

Vehicle	Displacement	Camber	Caster	Toe
Dodge Coronet (left front wheel) (static displacement = 3.0)	0.	0	0.75	0
	1.	0.41	0.00	-0.37
	2.	0.98	0.00	-0.59
	3.	1.26	0.00	-0.85
	4.	1.22	0.00	-1.05
	5.	0.95	0.00	-1.21
	6.	0.43	0.00	-1.36

Winnebago Motor Home - The attitudes of the wheels of a solid axle suspension are evaluated from axle angular displacement, suspension geometry (roll steer), and suspension compliance.

4. PRESENTED HERE ARE THE PARAMETER TABLE OUTPUT

PARAMETER VALUES - MODEL C - VEHICLE MODEL * VW CAMPMOBILE 1973

1	MS= 8.6000	2	MUF= 0.50700	3	MUR= 0.48900	4	ZF= 19.980	5	ZR= 19.920
6	A= 49.650	7	B= 44.850	8	TF= 54.800	9	TR= 57.200	10	TSR= 0.0
11	IX= 7380.0	12	IY= 24980.	13	IZ= 25660.	14	IXZ= 1140.0	15	IR= 0.69697E 06
16	= 0.0	17	RF= 0.15300E 06	18	STOP= 10.000	19	AKF1= 129.00	20	AKF2= 129.00
21	AKR3= 213.00	22	AKR4= 213.00	23	= 0.0	24	RR= 0.0	25	CF1P= 33.000
26	CF2P= 33.000	27	CR3P= 56.000	28	CR4P= 56.000	29	ZBAS= 0.0	30	KRS= 0.0
31	RW= 12.750	32	SCAL= 2000.0	33	FDT= 1.0000	34	A0= 2857.1	35	A1= 11.320
36	A2= 2845.5	37	A3= 0.36000	38	A4= -5944.2	39	TIR = 0.0	40	TDR = 0.0
41	KSC= 8592.0	42	NG= 16.300	43	= 0.0	44	= 0.0	45	= 0.0
46	= 0.0	47	IFW= 8.2700	48	IF = 0.69697E 06	49	IWF= 8.9300	50	IWR= 9.2800
51	IDR= 0.30000	52	ARR= 5.3750	53	TSF = 0.0	54	KFS = 0.0	55	PT= 0.59000
56	YSA1= 3.4700	57	YSA2= -3.4700	58	PHS1=-0.87300E-01	59	PHS2= 0.87300E-01	60	CTSW= 1.0000
61	IDF= 0.69697E 06	62	ARF= 0.69697E 06	63	P-IN= 0.0	64	Q-IN= 0.0	65	R-IN= 0.0
66	U-IN= 40.000	67	V-IN= 0.0	68	W-IN= 0.0	69	X-IN= 0.0	70	Y-IN= 0.0
71	Z-IN= -31.892	72	THIN= 0.23314E-02	73	PHIN= 0.0	74	PSIN= 0.0	75	DT= 0.10000E-01
76	TN= 5.0000	77	KT1= 1060.0	78	KT2= 1060.0	79	KT3= 1240.0	80	KT4= 1240.0
81	RPS1= 0.0	82	RPS2= 0.0	83	RPS3= 0.0	84	RPS4= 0.0	85	B1=-0.51200E-03
86	B2= 0.0	87	B3= 1.2600	88	B4= 0.11400E-06	89	D1DT= 0.0	90	D2DT= 0.0
91	D3DT= 0.0	92	DELF= -1.5400	93	DELR= -1.0300	94	DEL3= 0.0	95	PHDT= 0.0
96	PHIR= 0.0	97	DFW1= 0.0	98	DFW2= 0.0	99	U1PR= 0.0	100	U2PR= 0.0
101	U3PR= 0.0	102	U4PR= 0.0	103	S1PR= 0.0	104	S2PR= 0.0	105	S3PR= 0.0
106	S4PR= 0.0	107	PPRT= 1.0000	108	FREQ= 0.40000	109	RWSF= 20.000	110	TQMX= 4428.0
111	KTQ= 738.00	112	VC= 0.0	113	MTSW= 1.0000	114	OSWM= 62.000	115	TST= 1.0000
116	DSLP= 0.50000	117	CGAM= 3.0000	118	CS= 3.0000	119	TQR= 0.0	120	TQF= 0.0
121	PFL= 300.00	122	T1= 0.0	123	DSW= 0.0	124	= 0.0	125	ISW5= 0.0
126	SW15= 0.0	127	PQSW= 0.0	128	VTPS= 3.0000	129	VHTP= 0.0	130	AMCR= 0.38000E-01
131	ESP= 0.32000	132	KSL1= 44000.	133	KSL2= 44000.	134	AA1= 6.2000	135	AA2= 6.2000
136	CCR= 17.600	137	CFCR= 126.00	138	AP= 5.6800	139	EP1= 0.10000E-01	140	EP2=-0.10000E-01
141	AERO= 0.0	142	VYW = 0.0	143	DMXW= 0.0	144	DMZW= 0.0	145	RHDA= 0.11470E-06
146	CYP = 0.0	147	CYR = 0.0	148	CZAL= 0.0	149	CZQ = 0.0	150	CLP = 0.0
151	CLR = 0.0	152	CMAL= 0.0	153	CMQ = 0.0	154	CNP = 0.0	155	CNR = 0.0
156	SF = 4216.0	157	VLEN= 179.13	158	REWV= 1094.0	159	= 0.0	160	= 0.0
161	= 0.0	162	= 0.0	163	= 0.0	164	= 0.0	165	= 0.0
166	= 0.0	167	= 0.0	168	= 0.0	169	SNT= 73.000	170	SNS0= 75.000
171	SNS1= 75.000	172	SNSW= 2.0000	173	DIST= 0.0	174	PL = 0.0	175	TSCP= 0.25000
176	= 0.0	177	= 0.0	178	= 0.0	179	= 0.0	180	PASS= 4.0000
181	= 0.0	182	SI1= 0.14000	183	SI2= 0.14000	184	SI3= 0.19000	185	SI4= 0.19000
186	= 0.0	187	= 0.0	188	= 0.0	189	= 0.0	190	= 0.0
191	= 0.0	192	MTQB= 1.0000	193	DCSW= 0.0	194	LDF= 0.0	195	LDRF= 0.0
196	EK1= 0.0	197	EK2= 0.0	198	BMPL= 0.0	199	BMPS= 0.0	200	BMPH= 1.5000
201	XB= 0.0	202	APF1= 1.2400	203	APF2=-0.19800E-03	204	APR1= 1.1300	205	APR2=-0.11900E-03
206	MUSF= 0.80000	207	MUSR= 0.82000	208	BCON= 0.30000E-01	209	FCSW= 0.0	210	= 0.0
211	= 0.0	212	= 0.0	213	= 0.0	214	= 0.0	215	= 0.0
216	= 0.0	217	= 0.0	218	= 0.0	219	FEE1= 0.0	220	FEE2= 0.0
221	THE1= 0.0	222	THE2= 0.0	223	= 0.0	224	= 0.0	225	= 0.0
226	= 0.0	227	= 0.0	228	= 0.0	229	= 0.0	230	= 0.0
231	H1= 400.00	232	H2= 400.00	233	LAMD= 1.0000	234	= 0.0	235	= 0.0
236	= 0.0	237	= 0.0	238	BR1= 1.9000	239	BR2= 1.9000	240	BR3= 1.0000
241	BR4= 1.0000	242	KCF=-0.37200E-04	243	KCR=-0.22000E-04	244	KSR= 0.20000E-05	245	RB1=-0.67850E-03
246	RB2= 0.0	247	RB3= 1.4500	248	RB4= 0.16971E-06	249	AFK1=-0.24480E-02	250	AFK2= 0.28560E-02
251	AFK3= 1.0200	252	ARK1=-0.15600E-02	253	ARK2= 0.11496E-02	254	ARK3= 1.4400	255	DFC0= 0.0
256	DFC1=-0.10416E-02	257	DFC2=-0.70080E-02	258	DFC3= -5.2200	259	DRC0= 0.0	260	DRC1=-0.61920E-03
261	DRC2=-0.60480E-02	262	DRC3= -5.7600	263	CP0F= 0.0	264	CP1F= 0.0	265	CP2F= 0.0
266	CP0R= 0.29000	267	CP1R= 0.30000E-01	268	CP2R= 0.0	269	CR0F= 0.0	270	CR1F= 0.0
271	CR2F= 0.0	272	CR0R= 0.13000	273	CR1R= 0.30000E-01	274	CR2R= 0.0	275	= 0.0
276	= 0.0	277	BMPN= 0.0	278	TQB0= 0.0	279	TQB1= 0.0	280	= 0.0
281	= 0.0	282	= 0.0	283	= 0.0	284	HFC= 0.0	285	HRC= 3.5600
286	DRSW= 0.0	287	AXLE= 2.0000	288	DUAL= 0.0	289	TIRE= 4.0000	290	RDT = 1.0000
291	RA0 = -1441.2	292	RA1 = 16.440	293	RA2 = 3470.7	294	RA3 = 1.1700	295	RA4 = 4139.5

PARAMETER VALUES - MODEL C - VEHICLE MODEL * DODGE CORONET 1971

1	MS= 8.8200	2	MUF= 0.51000	3	MUR= 0.82000	4	ZF= 10.900	5	ZR= 10.800
6	A= 50.500	7	B= 67.500	8	TF= 59.800	9	TR= 61.800	10	TSR= 47.000
11	IX= 3832.0	12	1Y= 24003.	13	1Z= 24311.	14	IXZ= 530.00	15	1R= 550.00
16	= 0.0	17	RF= 40400.	18	STOP= 10.000	19	AKF1= 105.00	20	AKF2= 105.00
21	AKR3= 120.00	22	AKR4= 120.00	23	= 0.0	24	RR= -5100.0	25	CF1P= 40.000
26	CF2P= 40.000	27	CR3P= 38.000	28	CR4P= 38.000	29	ZBAS= 0.0	30	KRS= 0.20000E-01
31	RW= 13.200	32	SCAL= 1000.0	33	FOT= 0.75000	34	A0= 2701.0	35	A1= 10.140
36	A2= 2533.0	37	A3= 1.3000	38	A4= 4591.0	39	T1R = 0.0	40	TOR = 0.0
41	KSC= 8000.0	42	NG= 14.200	43	= 0.0	44	= 0.0	45	= 0.0
46	= 0.0	47	1FW= 6.4000	48	1F = 550.00	49	1WF= 9.4000	50	1WR= 9.4000
51	1DR= 0.70000	52	ARR= 2.7100	53	TSF = 0.0	54	KFS = 0.0	55	PT=-0.66000
56	YSA1= 4.5900	57	YSA2= -4.5900	58	PHS1=-0.13090	59	PHS2= 0.13090	60	CTSW= 1.0000
61	IDF= 0.0	62	ARF= 0.0	63	P-IN= 0.0	64	Q-IN= 0.0	65	R-1N= 0.0
66	U-IN= 40.000	67	V-1N= 0.0	68	W-1N= 0.0	69	X-IN= 0.0	70	Y-IN= 0.0
71	Z-1N= -23.372	72	TH1N=-0.13596E-01	73	PH1N= 0.0	74	PSIN= 0.0	75	DT= 0.50000E-02
76	TN= 5.0000	77	KT1= 1450.0	78	KT2= 1450.0	79	KT3= 1450.0	80	KT4= 1450.0
81	RPS1= 0.0	82	RPS2= 0.0	83	RPS3= 0.0	84	RPS4= 0.0	85	B1=-0.33000E-03
86	B2= 0.0	87	B3= 1.2280	88	B4= 0.75900E-07	89	D1DT= 0.0	90	D2DT= 0.0
91	D3DT= 0.0	92	DELF= -1.1000	93	DELR= -1.0800	94	DEL3= 0.0	95	PHDT= 0.0
96	PH1R= 0.0	97	DFW1= 0.0	98	DFW2= 0.0	99	U1PR= 0.0	100	U2PR= 0.0
101	U3PR= 0.0	102	U4PR= 0.0	103	S1PR= 0.0	104	S2PR= 0.0	105	S3PR= 0.0
106	S4PR= 0.0	107	PPRT= 1.0000	108	FREQ= 0.50000	109	RWSF= 15.000	110	TQMX= 0.0
111	KTQ= 0.0	112	VC= 0.0	113	MTSW= 1.0000	114	DSWM= 62.000	115	TST= 1.0000
116	DSLP= 0.50000	117	CGAM= 3.0000	118	CS= 3.0000	119	TQR= 0.0	120	TQF= 0.0
121	PFL= 300.00	122	T1= 0.0	123	DSW= 0.0	124	= 0.0	125	1SW5= 0.0
126	SW15= 0.0	127	PQSW= 0.0	128	VTPS= 3.0000	129	VHTP= 0.0	130	AMCR= 0.60000E-01
131	ESP= 16.000	132	KSL1= 55900.	133	KSL2= 55900.	134	AA1= 6.6200	135	AA2= 6.6200
136	CCR= 11.000	137	CFCR= 54.000	138	AP= 5.2000	139	EP1= 0.45000	140	EP2=-0.45000
141	AERD= 0.0	142	VYW = 88.000	143	DMXW= 0.30000E-01	144	OMZW= 0.40000E-01	145	RHDA= 0.10000E-02
146	CYP = 0.10000E 00	147	CYR = 0.10000E-01	148	CZAL= 0.10000E-02	149	CZQ = 0.60000E-02	150	CLP = 0.10000E-02
151	CLR = 0.10000E-02	152	CMAL= 0.10000E-03	153	CMQ = 0.10000E-03	154	CNP = 0.30000E-03	155	CNR = 0.40000E-03
156	SF = 500.00	157	VLEN= 0.0	158	REWV= 0.0	159	= 0.0	160	= 0.0
161	= 0.0	162	= 0.0	163	= 0.0	164	= 0.0	165	= 0.0
166	= 0.0	167	= 0.0	168	= 0.0	169	SNT= 73.000	170	SNS0= 73.000
171	SNS1= 73.000	172	SNSW= 2.0000	173	DIST= 0.0	174	PL = 0.0	175	TSCP= 0.25000
176	= 0.0	177	= 0.0	178	= 0.0	179	= 0.0	180	PASS= 4.0000
181	= 0.0	182	S11= 0.17000	183	S12= 0.17000	184	S13= 0.17000	185	SI4= 0.17000
186	= 0.0	187	= 0.0	188	= 0.0	189	= 0.0	190	= 0.0
191	= 0.0	192	MTQB= 1.0000	193	DCSW= 0.0	194	LDF= 0.0	195	LDRF= 0.0
196	EK1= 0.0	197	EK2= 0.0	198	BMPL= 0.0	199	BMPS= 0.0	200	BMPH= 1.5000
201	XB= 0.0	202	APF1= 0.94000	203	APF2=-0.80000E-04	204	APR1= 0.94000	205	APR2=-0.80000E-04
206	MUSF= 0.65000	207	MUSR= 0.65000	208	BCDN= 0.30000E-01	209	FCSW= 0.0	210	= 0.0
211	= 0.0	212	= 0.0	213	= 0.0	214	= 0.0	215	= 0.0
216	= 0.0	217	= 0.0	218	= 0.0	219	FEE1= 0.0	220	FEE2= 0.0
221	THE1= 0.0	222	THE2= 0.0	223	= 0.0	224	= 0.0	225	= 0.0
226	= 0.0	227	= 0.0	228	= 0.0	229	= 0.0	230	= 0.0
231	H1= 400.00	232	H2= 400.00	233	LAMD= 1.0000	234	= 0.0	235	= 0.0
236	= 0.0	237	= 0.0	238	BR1= 1.0000	239	BR2= 1.0000	240	BR3= 0.67000
241	BR4= 0.67000	242	KCF=-0.39300E-04	243	KCR=-0.33200E-04	244	KSR= 0.17500E-05	245	RB1=-0.33000E-03
246	RB2= 0.0	247	RB3= 1.2280	248	RB4= 0.75900E-07	249	AFK1=-0.31800E-02	250	AFK2= 0.34900E-02
251	AFK3= 1.4040	252	ARK1=-0.31800E-02	253	ARK2= 0.34900E-02	254	ARK3= 1.4040	255	OFC0= 0.0
256	OFC1=-0.15000E-02	257	OFC2=-0.52440E-02	258	DFC3= -5.5920	259	ORC0= 0.0	260	ORC1=-0.15000E-02
261	DRC2=-0.52440E-02	262	DRC3= -5.5920	263	CP0F=-0.13000	264	CP1F=-0.30000E-01	265	CP2F= 0.0
266	CP0R= 0.15000	267	CP1R= 0.15000E-01	268	CP2R= 0.0	269	CR0F= 0.89000E-01	270	CR1F= 0.10000E-01
271	CR2F= 0.0	272	CR0R= 0.0	273	CR1R= 0.0	274	CR2R= 0.0	275	= 0.0
276	= 0.0	277	BMPN= 0.0	278	TQB0= 0.0	279	TQB1= 0.0	280	= 0.0
281	= 0.0	282	= 0.0	283	= 0.0	284	HFC= 2.7000	285	HRC= 3.9000
286	DRSW= 0.0	287	AXLE= 1.0000	288	DUAL= 0.0	289	TIRE= 4.0000	290	RDT = 0.75000
291	RA0 = 2701.0	292	RA1 = 10.140	293	RA2 = 2533.0	294	RA3 = 1.3000	295	RA4 = 4591.0

PARAMETER VALUES - MODEL C - VEHICLE MODEL * WINNABAGO MOTOR HOME TYPE A (DODGE RM 400/158.5" WB)

1	MS= 24.609 ,	2	MUF= 1.7210 ,	3	MUR= 2.8880 ,	4	ZF= 36.300 ,	5	ZR= 36.190 ,
6	A= 99.410 ,	7	B= 59.090 ,	8	TF= 66.150 ,	9	TR= 66.120 ,	10	TSR= 41.240 ,
11	IX= 40300. ,	12	IY= 0.21910E 06,	13	IZ= 0.21650E 06,	14	IXZ= 7100.0 ,	15	IR= 2400.0 ,
16	= 0.0 ,	17	RF= 0.15300E 06,	18	STDP= 10.000 ,	19	AKF1= 450.00 ,	20	AKF2= 450.00 ,
21	AKR3= 875.00 ,	22	AKR4= 875.00 ,	23	= 0.0 ,	24	RR= 0.15300E 06,	25	CF1P= 100.00 ,
26	CF2P= 100.00 ,	27	CR3P= 150.00 ,	28	CR4P= 150.00 ,	29	ZBAS= 0.0 ,	30	KRS=-0.10000E-01,
31	RW= 16.870 ,	32	SCAL= 4000.0 ,	33	FDT= 1.0000 ,	34	A0= 635.20 ,	35	A1= 11.980 ,
36	A2= 5447.9 ,	37	A3= 1.8900 ,	38	A4= 6306.2 ,	39	TIR = 56.620 ,	40	TDR = 75.620 ,
41	KSC= 8000.0 ,	42	NG= 17.500 ,	43	= 0.0 ,	44	= 0.0 ,	45	= 0.0 ,
46	= 0.0 ,	47	IFW= 27.000 ,	48	IF = 1500.0 ,	49	IWF= 21.300 ,	50	IWR= 48.000 ,
51	IDR= 1.3000 ,	52	ARR= 4.5600 ,	53	TSF = 31.000 ,	54	KFS = 0.70000E-01,	55	PT= 1.3100 ,
56	YSA1= 6.0800 ,	57	YSA2= -6.0800 ,	58	PHS1=-0.12217 ,	59	PHS2= 0.12217 ,	60	CTSW= 1.0000 ,
61	IOF= 0.0 ,	62	ARF= 0.0 ,	63	P-IN= 0.0 ,	64	Q-IN= 0.0 ,	65	R-IN= 0.0 ,
66	U-IN= 40.000 ,	67	V-IN= 0.0 ,	68	W-IN= 0.0 ,	69	X-IN= 0.0 ,	70	Y-IN= 0.0 ,
71	Z-IN= -52.478 ,	72	THIN=-0.77222E-04,	73	PHIN= 0.0 ,	74	PSIN= 0.0 ,	75	DT= 0.10000E-01,
76	TN= 5.0000 ,	77	KT1= 3040.0 ,	78	KT2= 3040.0 ,	79	KT3= 3040.0 ,	80	KT4= 3040.0 ,
81	RPS1= 0.0 ,	82	RPS2= 0.0 ,	83	RPS3= 0.0 ,	84	RPS4= 0.0 ,	85	B1=-0.23600E-03,
86	B2= 0.0 ,	87	B3= 1.3200 ,	88	B4= 0.29700E-07,	89	D1DT= 0.0 ,	90	D2DT= 0.0 ,
91	D3DT= 0.0 ,	92	DELF= 0.0 ,	93	DELR= 0.0 ,	94	DEL3= 0.0 ,	95	PHDT= 0.0 ,
96	PHIR= 0.0 ,	97	DFW1= 0.0 ,	98	DFW2= 0.0 ,	99	U1PR= 0.0 ,	100	U2PR= 0.0 ,
101	U3PR= 0.0 ,	102	U4PR= 0.0 ,	103	S1PR= 0.0 ,	104	S2PR= 0.0 ,	105	S3PR= 0.0 ,
106	S4PR= 0.0 ,	107	PPRT= 1.0000 ,	108	FREQ= 0.40000 ,	109	RWSF= 20.000 ,	110	TQMX= 4428.0 ,
111	KTQ= 738.00 ,	112	VC= 0.0 ,	113	MTSW= 1.0000 ,	114	DSWM= 62.000 ,	115	TST= 1.0000 ,
116	DSLP= 0.50000 ,	117	CGAM= 3.0000 ,	118	CS= 3.0000 ,	119	TQR= 0.0 ,	120	TQF= 0.0 ,
121	PFL= 300.00 ,	122	T1= 0.0 ,	123	OSW= 0.0 ,	124	= 0.0 ,	125	ISW5= 0.0 ,
126	SW15= 0.0 ,	127	PQSW= 0.0 ,	128	VTPS= 3.0000 ,	129	VHTP= 0.0 ,	130	AMCR= 0.78000E-01,
131	ESP= 0.27900 ,	132	KSL1= 0.15000E 06,	133	KSL2= 0.15000E 06,	134	AA1= 8.0200 ,	135	AA2= 8.0200 ,
136	CCR= 11.000 ,	137	CFCR= 120.00 ,	138	AP= 7.5000 ,	139	EP1= 0.90000E-02,	140	EP2=-0.90000E-02,
141	AERD= 0.0 ,	142	VYW = 0.0 ,	143	DMXW= 0.0 ,	144	OMZW= 0.0 ,	145	RHDA= 0.11470E-06,
146	CYP = 0.0 ,	147	CYR = 0.0 ,	148	CZAL= 0.0 ,	149	CZQ = 0.0 ,	150	CLP = 0.0 ,
151	CLR = 0.0 ,	152	CMAL= 0.0 ,	153	CMQ = 0.0 ,	154	CNP = 0.0 ,	155	CNR = 0.0 ,
156	SF = 9100.0 ,	157	VLEN= 294.00 ,	158	REWV= 1094.0 ,	159	= 0.0 ,	160	= 0.0 ,
161	= 0.0 ,	162	= 0.0 ,	163	= 0.0 ,	164	= 0.0 ,	165	= 0.0 ,
166	= 0.0 ,	167	= 0.0 ,	168	= 0.0 ,	169	SNT= 73.000 ,	170	SNS0= 75.000 ,
171	SNS1= 75.000 ,	172	SNSW= 2.0000 ,	173	DIST= 0.0 ,	174	PL = 0.0 ,	175	TSCP= 0.25000 ,
176	= 0.0 ,	177	= 0.0 ,	178	= 0.0 ,	179	= 0.0 ,	180	PASS= 4.0000 ,
181	= 0.0 ,	182	SI1= 0.20000 ,	183	SI2= 0.20000 ,	184	SI3= 0.20000 ,	185	SI4= 0.20000 ,
186	= 0.0 ,	187	= 0.0 ,	188	= 0.0 ,	189	= 0.0 ,	190	= 0.0 ,
191	= 0.0 ,	192	MTQB= 1.0000 ,	193	DCSW= 0.0 ,	194	LDF= 0.0 ,	195	LDRF= 0.0 ,
196	EK1=-0.18000E-02,	197	EK2= 0.18000E-02,	198	BMPL= 0.0 ,	199	BMPS= 0.0 ,	200	BMPH= 1.5000 ,
201	XB= 0.0 ,	202	APF1= 1.0400 ,	203	APF2=-0.75800E-04,	204	APR1= 1.0400 ,	205	APR2=-0.75800E-04,
206	MUSF= 0.72000 ,	207	MUSR= 0.72000 ,	208	BCON= 0.30000E-01,	209	FCSW= 0.0 ,	210	= 0.0 ,
211	= 0.0 ,	212	= 0.0 ,	213	= 0.0 ,	214	= 0.0 ,	215	= 0.0 ,
216	= 0.0 ,	217	= 0.0 ,	218	= 0.0 ,	219	FEE1= 0.34900E-01,	220	FEE2=-0.34900E-01,
221	THE1= 0.69800E-01,	222	THE2= 0.69800E-01,	223	= 0.0 ,	224	= 0.0 ,	225	= 0.0 ,
226	= 0.0 ,	227	= 0.0 ,	228	= 0.0 ,	229	= 0.0 ,	230	= 0.0 ,
231	H1= 600.00 ,	232	H2= 600.00 ,	233	LAMD= 0.0 ,	234	= 0.0 ,	235	= 0.0 ,
236	= 0.0 ,	237	= 0.0 ,	238	BR1= 1.1300 ,	239	BR2= 1.1300 ,	240	BR3= 1.0000 ,
241	BR4= 1.0000 ,	242	KCF=-0.20000E-04,	243	KCR=-0.20000E-04,	244	KSR= 0.15000E-05,	245	RB1=-0.23600E-03,
246	RB2= 0.0 ,	247	RB3= 1.3200 ,	248	RB4= 0.29700E-07,	249	AFK1=-0.15700E-02,	250	AFK2= 0.14800E-02,
251	AFK3= 1.6080 ,	252	ARK1=-0.15700E-02,	253	ARK2= 0.14800E-02,	254	ARK3= 1.6080 ,	255	DFC0= 0.0 ,
256	DFC1=-0.62400E-03,	257	DFC2= 0.24000E-02,	258	DFC3= -9.1320 ,	259	DRC0= 0.0 ,	260	DRC1=-0.62400E-03,
261	DRC2= 0.24000E-02,	262	DRC3= -9.1320 ,	263	CP0F= 0.0 ,	264	CP1F= 0.0 ,	265	CP2F= 0.0 ,
266	CP0R= 0.0 ,	267	CP1R= 0.0 ,	268	CP2R= 0.0 ,	269	CR0F= 0.0 ,	270	CR1F= 0.0 ,
271	CR2F= 0.0 ,	272	CR0R= 0.0 ,	273	CR1R= 0.0 ,	274	CR2R= 0.0 ,	275	= 0.0 ,
276	= 0.0 ,	277	BMPN= 0.0 ,	278	TQB0= 0.0 ,	279	TQB1= 0.0 ,	280	= 0.0 ,
281	= 0.0 ,	282	= 0.0 ,	283	= 0.0 ,	284	HFC= 0.0 ,	285	HRC= 0.0 ,
286	DRSW= 0.0 ,	287	AXLE= 0.0 ,	288	DUAL= 1.0000 ,	289	TIRE= 4.0000 ,	290	ROT = 1.0000 ,
291	RA0 = 635.20 ,	292	RA1 = 11.980 ,	293	RA2 = 5447.9 ,	294	RA3 = 1.8900 ,	295	RA4 = 6306.2 ,

5. List of APL Operational Vehicle Data Decks

Vehicle	Suspension Front	Suspension Rear
VW Super Beetle (71)	I	I
Dodge Coronet (71)	I	S
Pontiac Trans Am (71)	I	S
Chevrolet Brookwood Station Wagon (71)	I	S
Chevrolet Caprice Station Wagon (73)	I	S
F-250 Pickup with 11 foot Open Road Camper (74)	I	S
VW Campmobile (74)	I	I
Winnebago Motor Home Type A (74) (Dodge Rm 400/158.5" WB)	S	S,D
Open Road Motor Home Type C (74) (Dodge MB 300/127" WB)	I	S,D
Ford Econoline Van (69)	I	S
Ford F-250 Pickup (74)	I	S
GMC Intercity Bus (66)	S	S,D
White Tractor (74)	S	S,D
Jeep Wagoneer (74)	S	S
Chevrolet NOVA (74)	I	S
Chevrolet NOVA (75)	I	S
Ford Torino (75)	I	S
Ford Mustang (71)	I	S

I = independent
S = solid
D = dual tires, one rear axle

APPENDIX F

PERFORMANCE COMPARISON VARIABLE GRAPHS

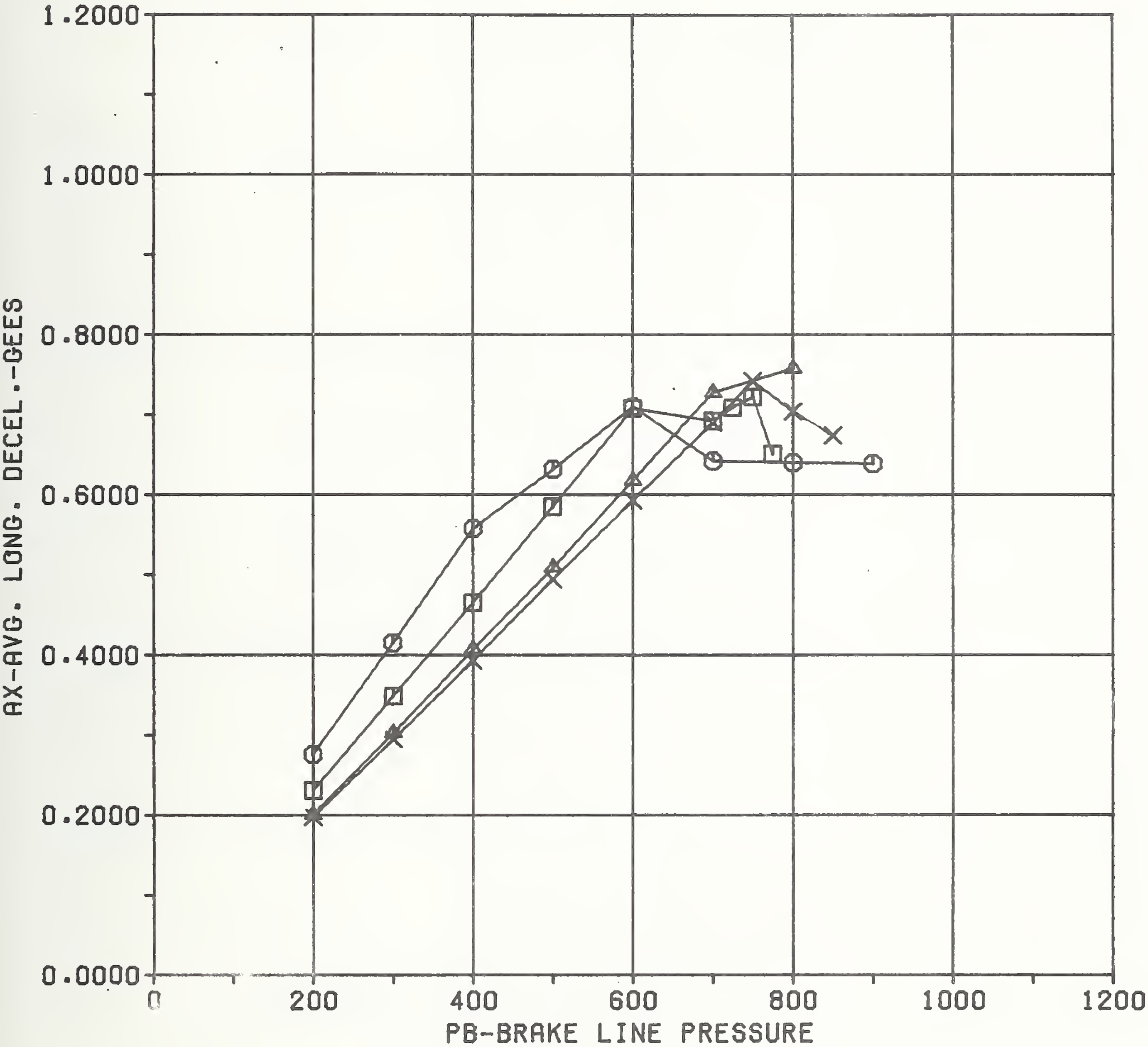
1. VHTP #1 - STRAIGHT LINE BRAKING

A_x - Average Longitudinal Deceleration from 35 mph to 10 mph (GEES)

P_B - Brake Line Pressure (PSI)

FIG. 1 *** AVG. LONG. DECEL. VS. BRAKE LINE PRESSURE ***

(CALSPAN, O.E. TIRES, STRIGHT LINE BRAKING)



● - DODGE CORONET

▪ - CHEVY BROOKWOOD

▲ - PONTIAC TRANS AM

× - VW SUPERBEETLE

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2. VHTP #2 - BRAKING IN A TURN

A_x - Average Longitudinal Deceleration from 35 mph to 10 mph (GEES)

P_B - Brake Line Pressure (PSI)

BETADOT - Peak Vehicle Sideslip Angle Rate (RADIANS/SEC)

$R_0(1/R)$ - Average Path Curvature Ratio Relative to Initial Turn

FIG. 2 *** AVG. LONG. DECEL. VS. BRAKE LINE PRESSURE ***

(CALSPAN, O.E. TIRES, BRAKING IN A TURN)

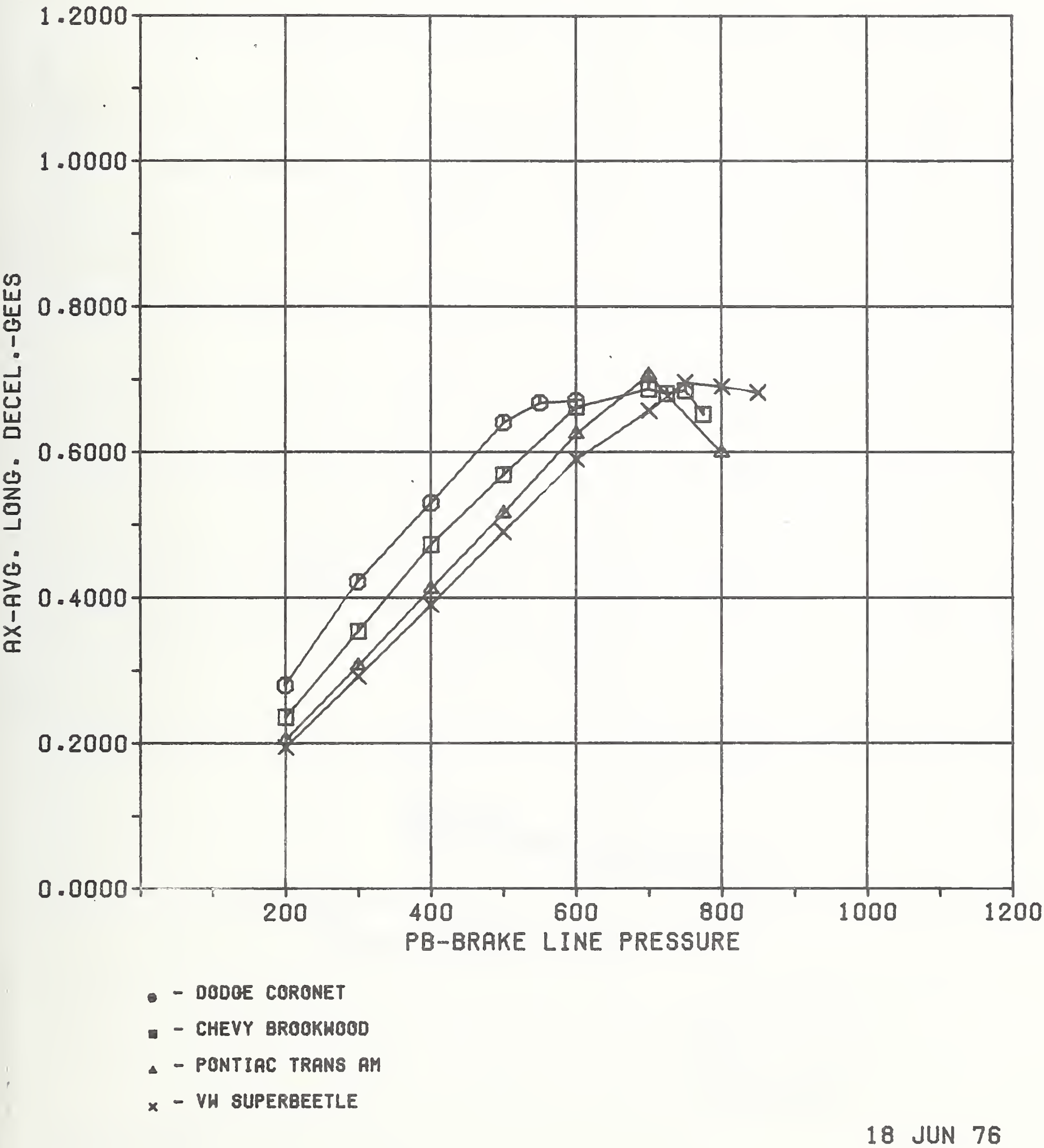

FIG. 3 *** SIDESLIP RATE VS. AVG. LONG. DECEL. ***

(CALSPAN, O.E. TIRES, BRAKING IN A TURN)

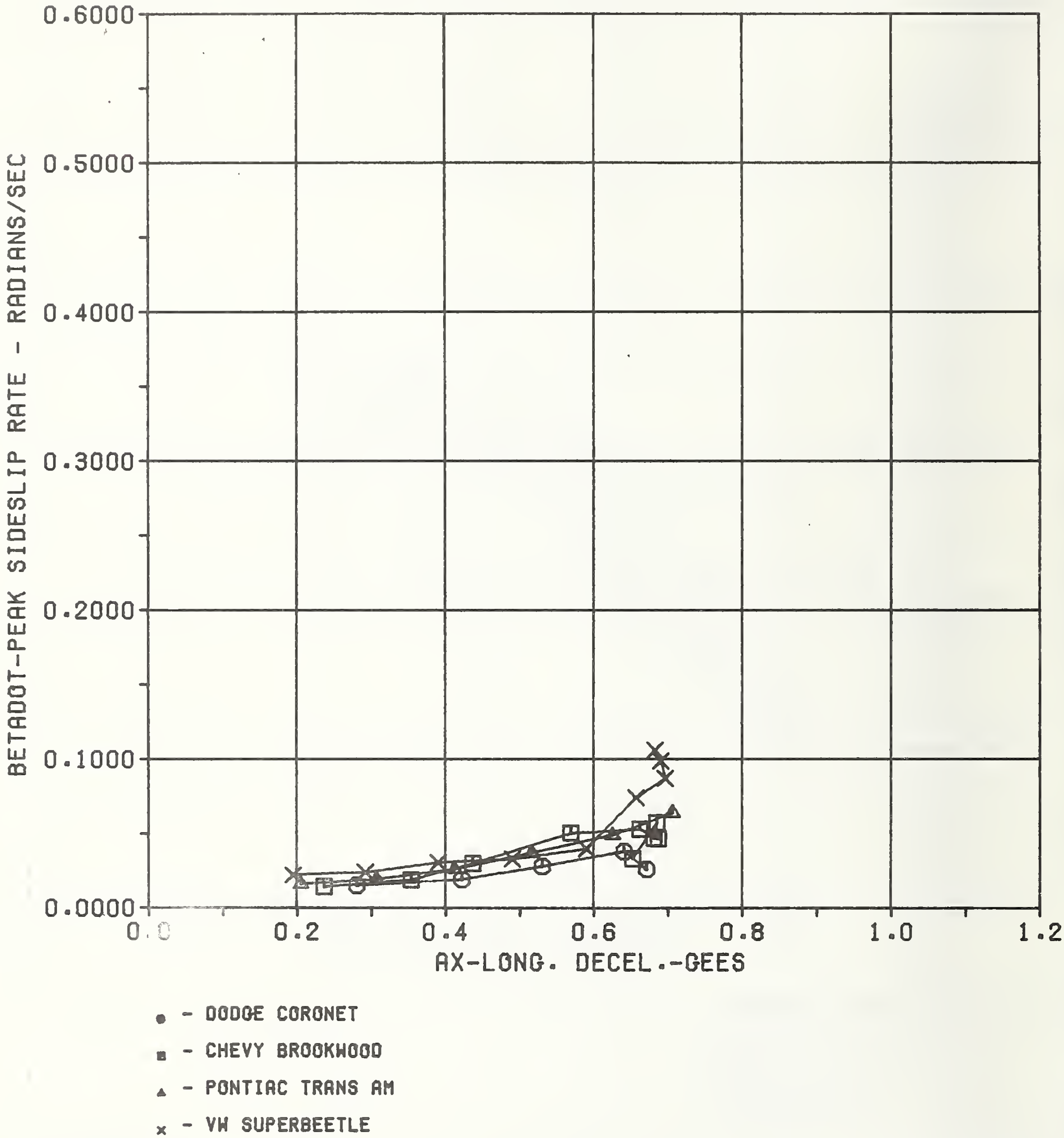

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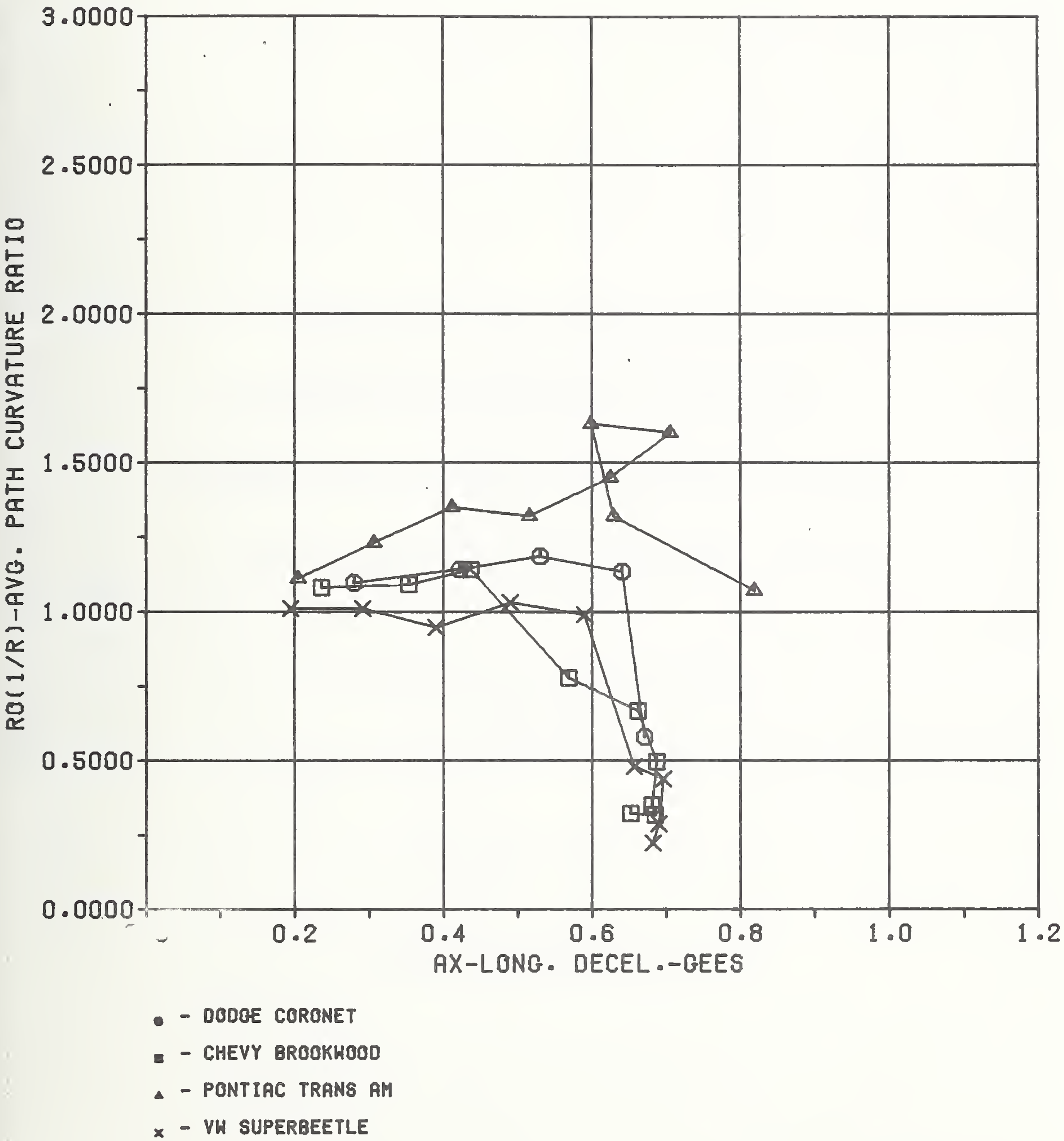
FIG. 4 *** AVG. PATH CURV. RATIO VS. AVG. LONG. DECEL. ***

(CALSPAN, O.E. TIRES, BRAKING IN A TURN)



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3. VHTP #3 - TURNING ON A ROUGH ROAD

f - Roadroughness Fundamental Frequency - Determined by Spacing of the Disturbance Elements in Each Grid (HZ)

$R_0(1/R)$ - Average Path Curvature Ratio Relative to the Initial Turn

BETADOT - Peak Vehicle Sideslip Angle Rate (RADIANS/SEC)

FIG. 5 *** SIDESLIP RATE VS. ROADROUGHNESS FREQ. ***

(CALSPAN, O.E. TIRES, TURNING ON A ROUGH ROAD)

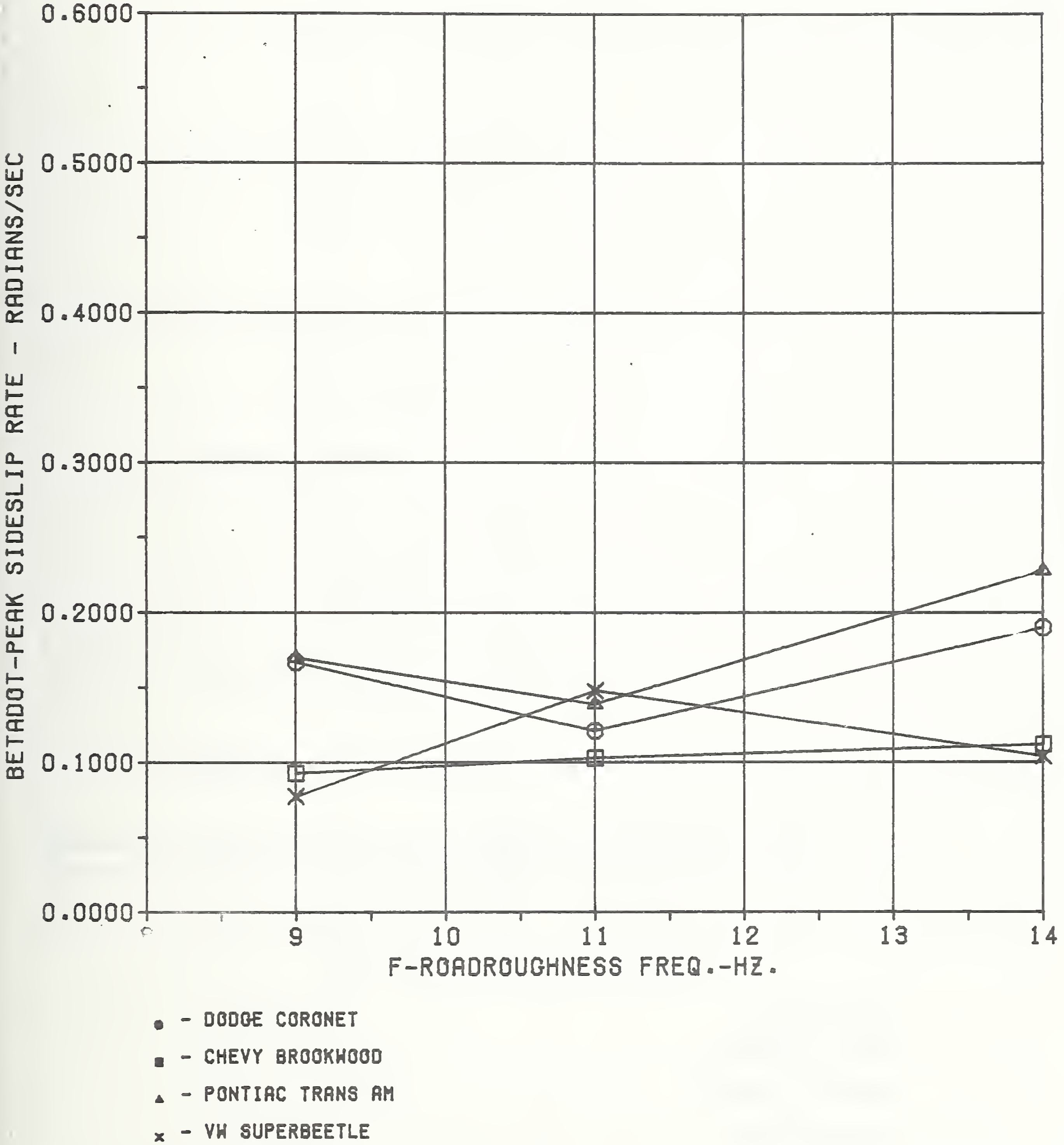

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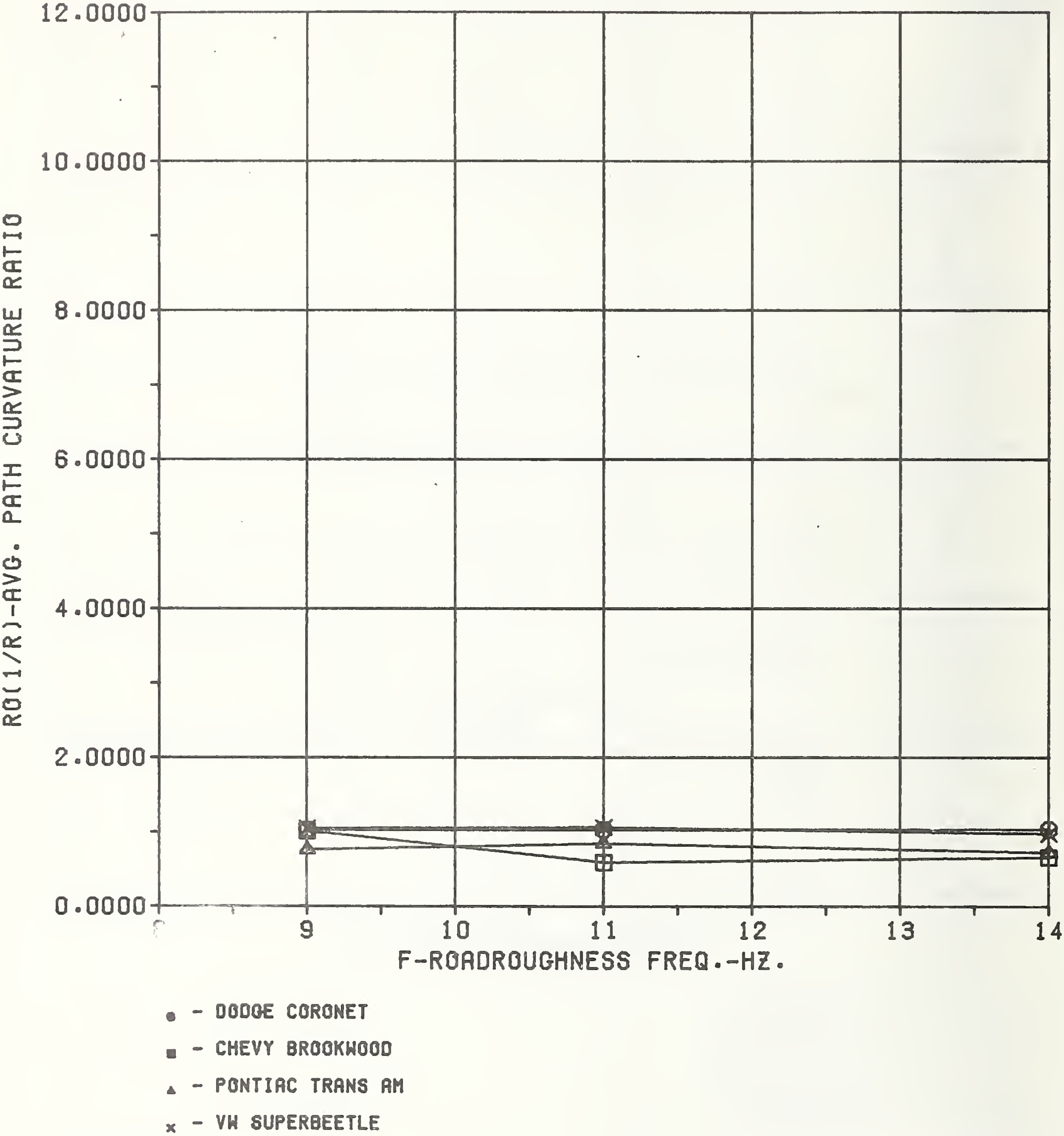
FIG. 6 *** AVG. PATH CURVATURE RATIO VS. ROADROUGHNESS FREQ. ***

(CALSPAN, O.E. TIRES, TURNING ON A ROUGH ROAD)



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4. VHTP #4 - TRAPEZOIDAL STEER

A_y - Peak Lateral Acceleration (GEES)

SIGMA - Normalized Steer Angle (DEGREES)

R - Peak Yaw Rate (RADIANS/SEC)

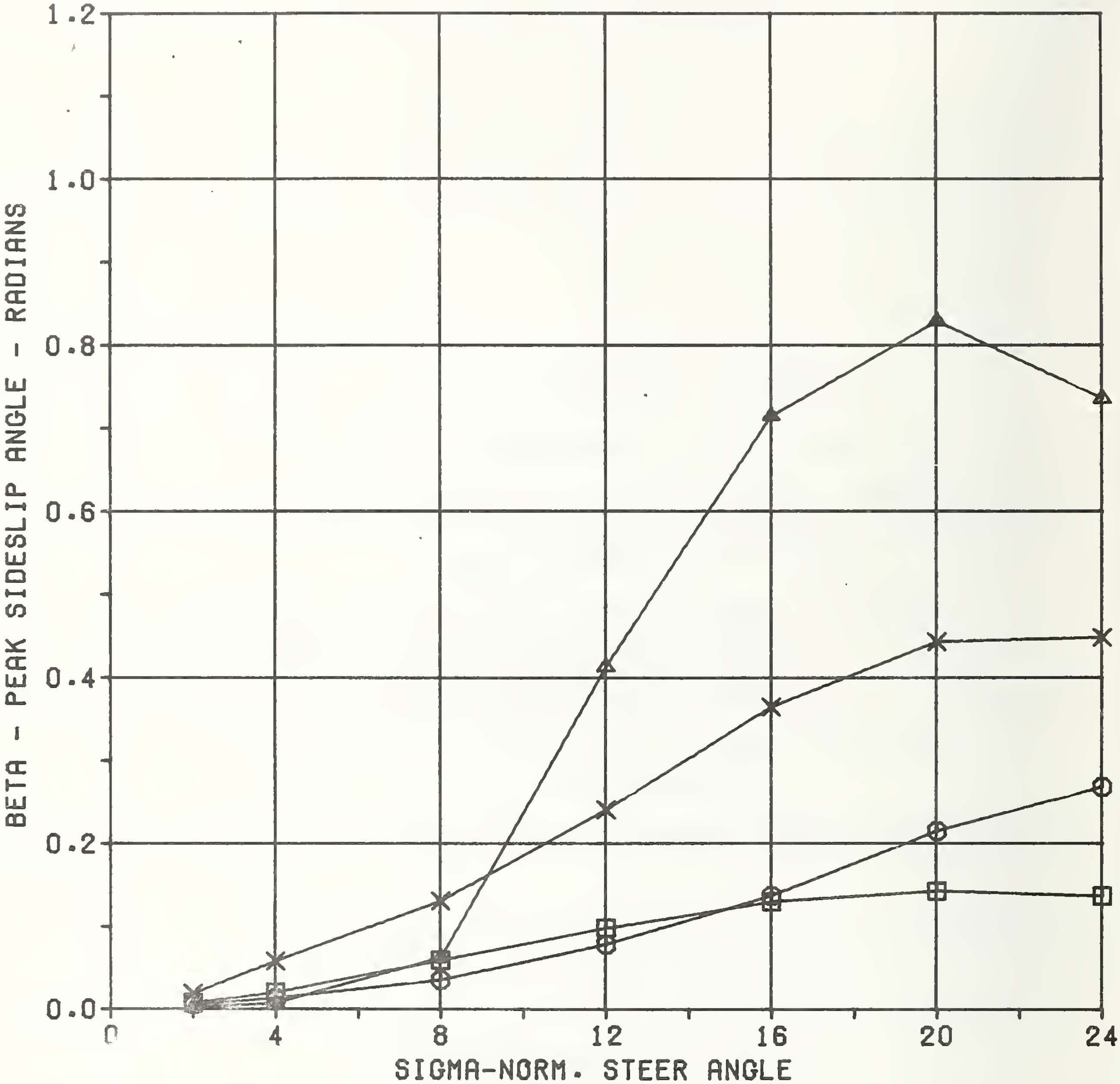
$R_s(1/R)$ - Path Curvature Response Averaged Over Two Seconds and Ratioed to a Reference Path Curvature Deriving from a Steady Turn of 40 mph and 1.0g A_y

BETADOT - Peak Vehicle Sideslip Angle Rate (RADIANS/SEC)

BETA - Peak Vehicle Sideslip Angle (RADIANS)

FIG. 7 *** SIDESLIP ANGLE VERSUS NORMALIZED STEER ANGLE ***

(CALSPAN, O.E. TIRES, TRAPEZOIDAL STEER)



● - DODGE CORONET

■ - CHEVY BROOKWOOD

▲ - PONTIAC TRANS AM

× - VW SUPERBEETLE

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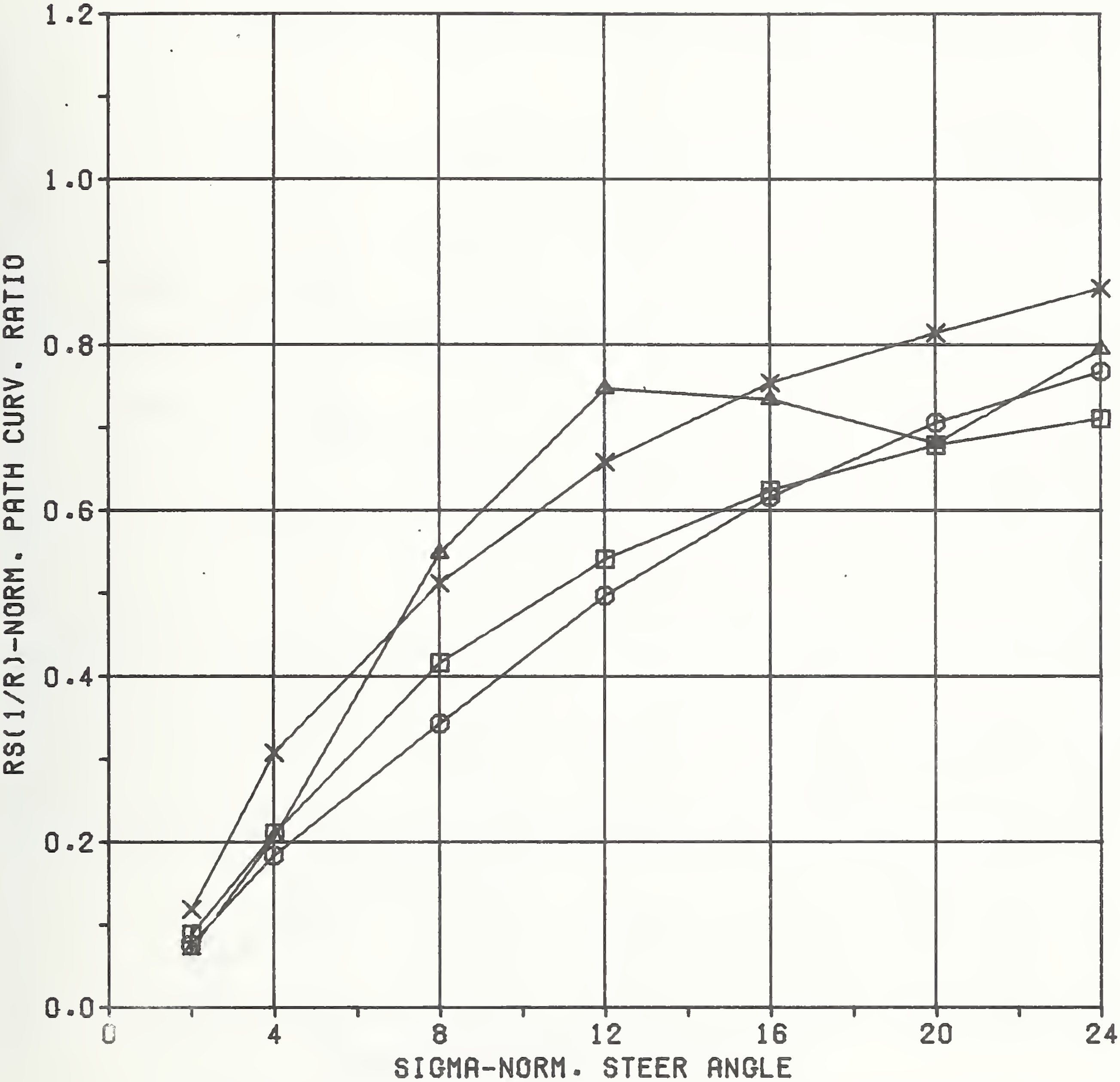
FIG. 8 *** NORM. CURVATURE RATIO VS. NORM. STEER ANGLE ***

(CALSPAN, O.E. TIRES, TRAPEZOIDAL STEER)



● - DODGE CORONET

■ - CHEVY BROOKWOOD

▲ - PONTIAC TRANS AM

× - VW SUPERBEETLE

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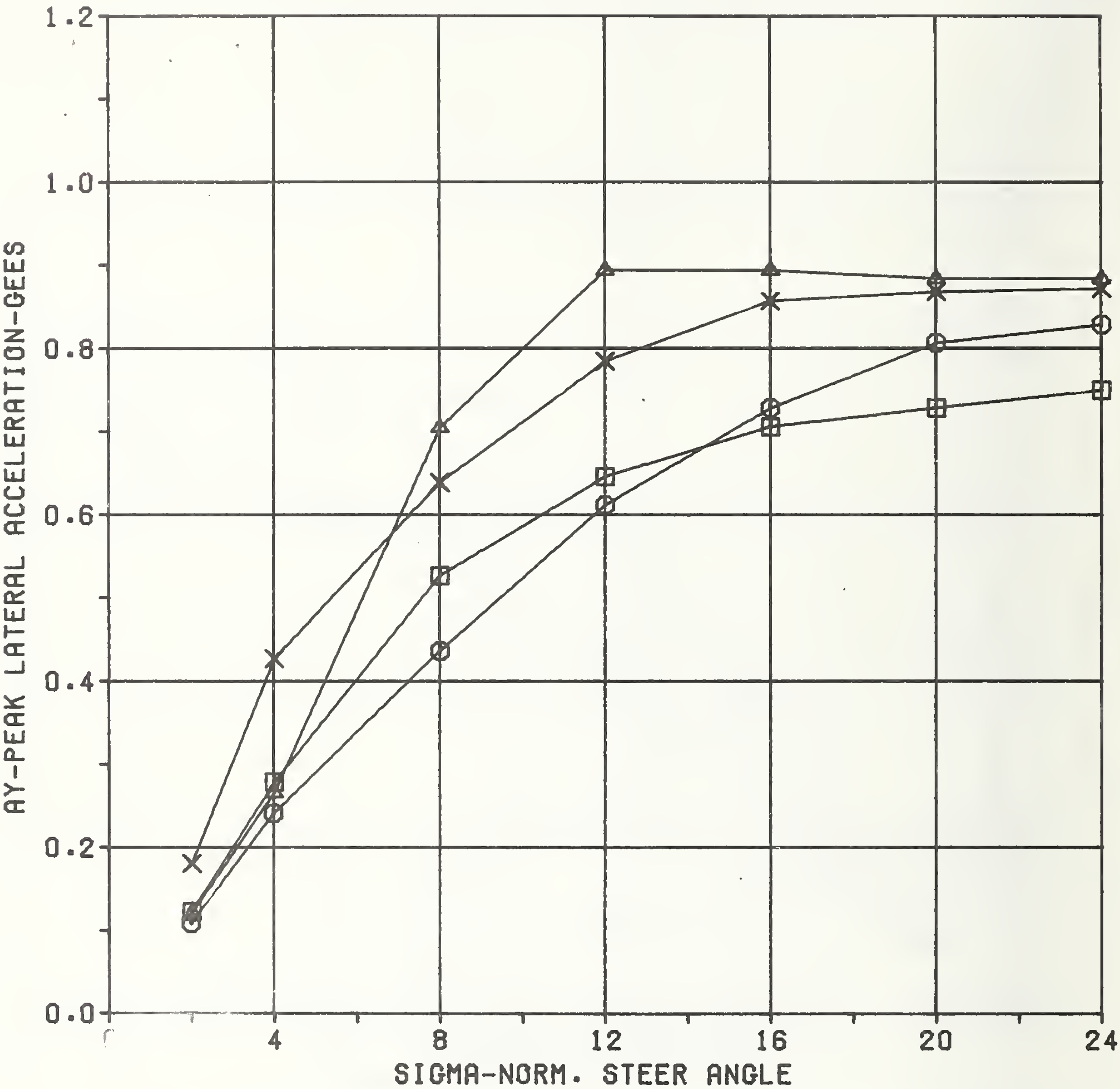
FIG. 9 *** LATERAL ACCECERATION VS. NORM. STEER ANGLE ***

(CALSPAN, O.E. TIRES, TRAPEZOIDAL STEER)



● - DODGE CORONET

■ - CHEVY BROOKWOOD

▲ - PONTIAC TRANS AM

× - VW SUPERBEETLE

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FIG. 10 *** YAW RATE VERSUS NORM. STEER ANGLE ***

(CALSPAN, O.E. TIRES, TRAPEZOIDAL STEER)

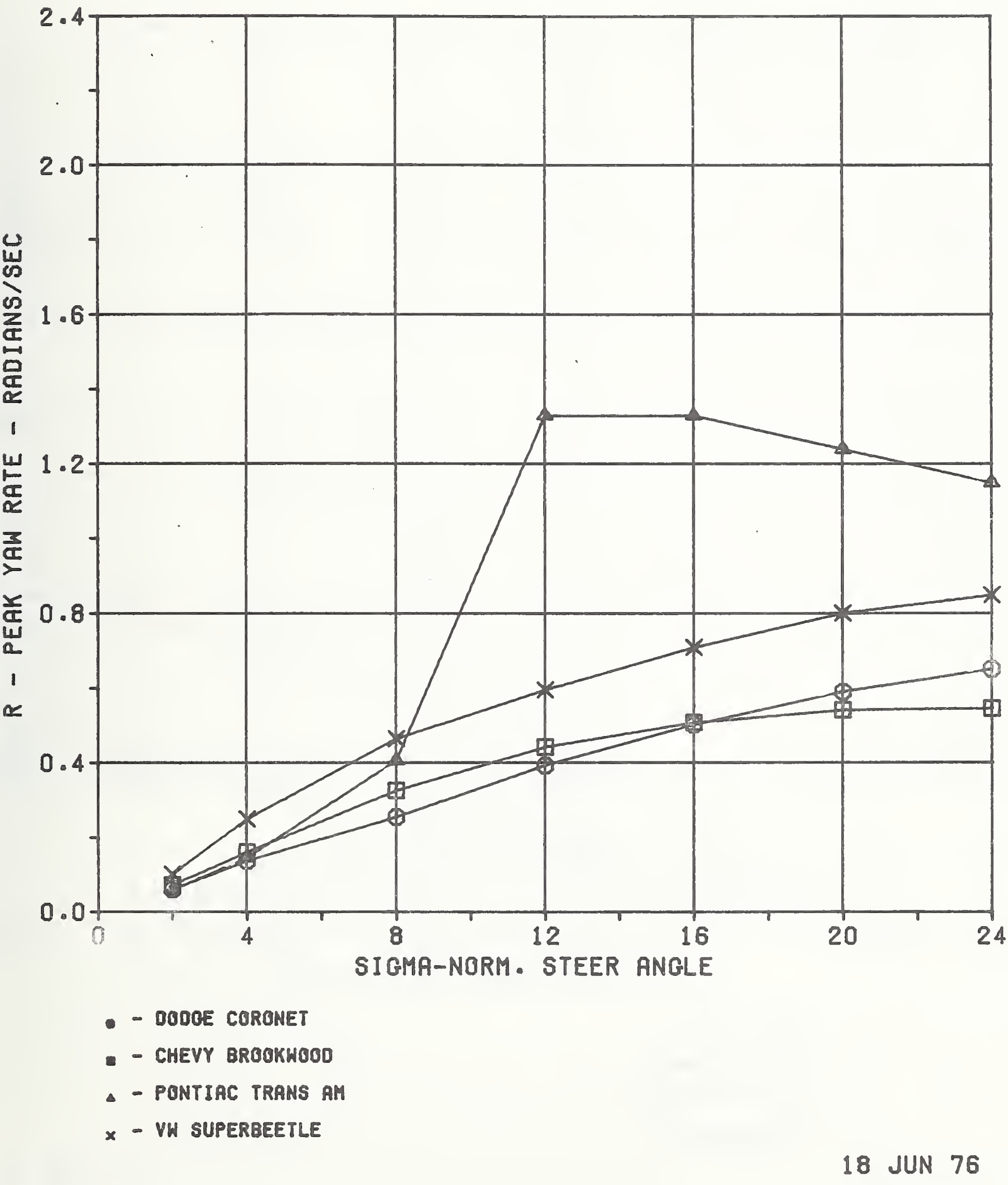
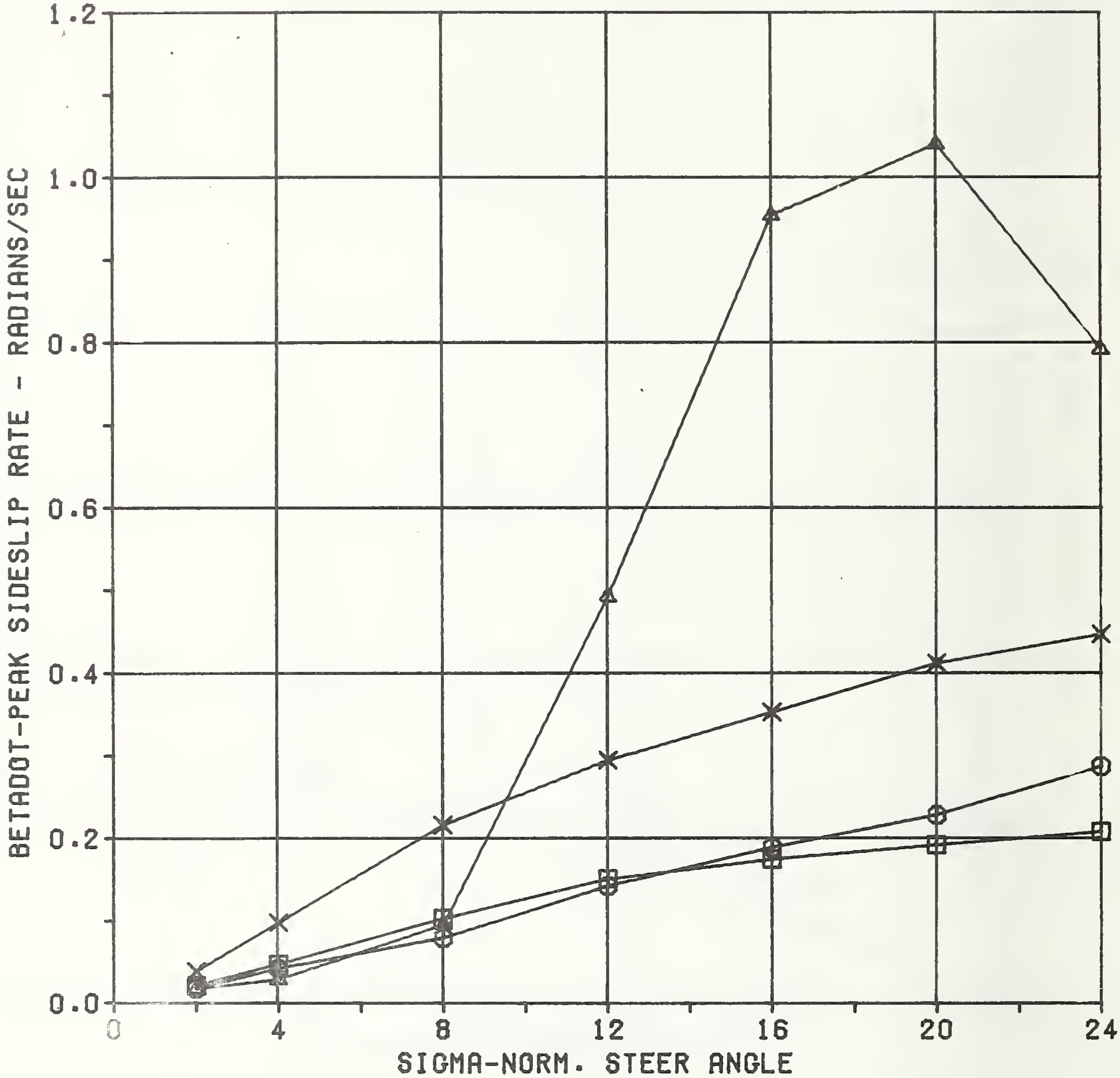


FIG. 11 *** SIDESLIP RATE VERSUS NORM. STEER ANGLE ***

(CALSPAN, O.E. TIRES, TRAPEZOIDAL STEER)



● - DODGE CORONET

■ - CHEVY BROOKWOOD

▲ - PONTIAC TRANS AM

x - VW SUPERBEETLE

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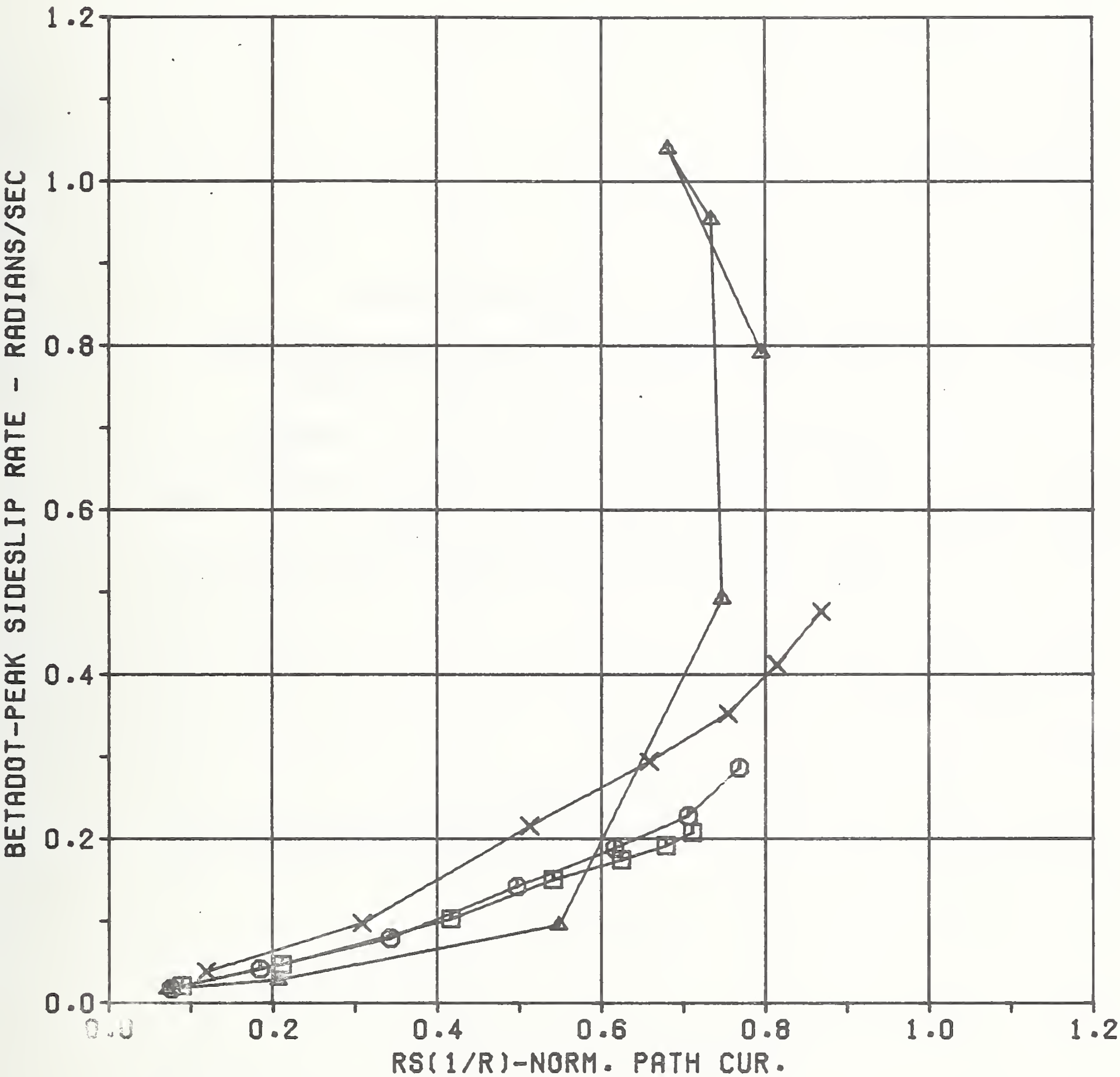
FIG. 12 *** SIDESLIP RATE VERSUS NORM. PATH CURVATURE RATIO ***

(CALSPAN, O.E. TIRES, TRAPEZOIDAL STEER)



● - DODGE CORONET

■ - CHEVY BROOKWOOD

▲ - PONTIAC TRANS AM

× - VW SUPERBEETLE

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5. VHTP #5 - SINUSOIDAL STEER

DEL PSI - Vehicle Heading Angle Deviation
After 3.4 Seconds (RADIANS)

SIGMA - Normalized Steer Angle (DEGREES)

DEL - Lane Change Deviation from "IDEAL" Lane
Change Displacement (FEET)

BETA - Peak Vehicle Sideslip Angle (RADIANS)

FIG. 13 *** HEADING ANGLE DEV. VS. NORM. STEER ANGLE ***

(CALSPAN, O.E. TIRES, SINUSOIDAL STEER-45 MPH)

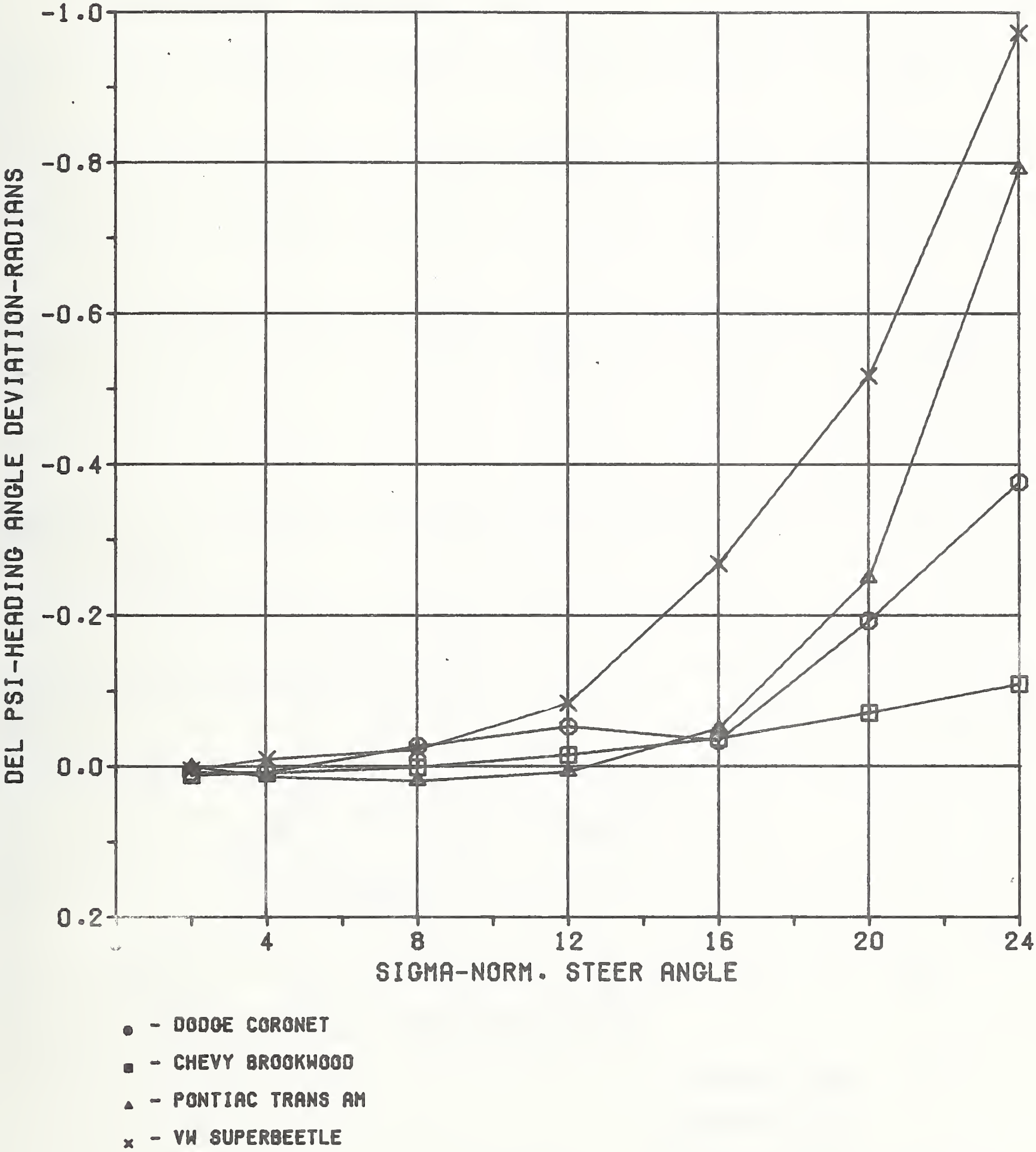

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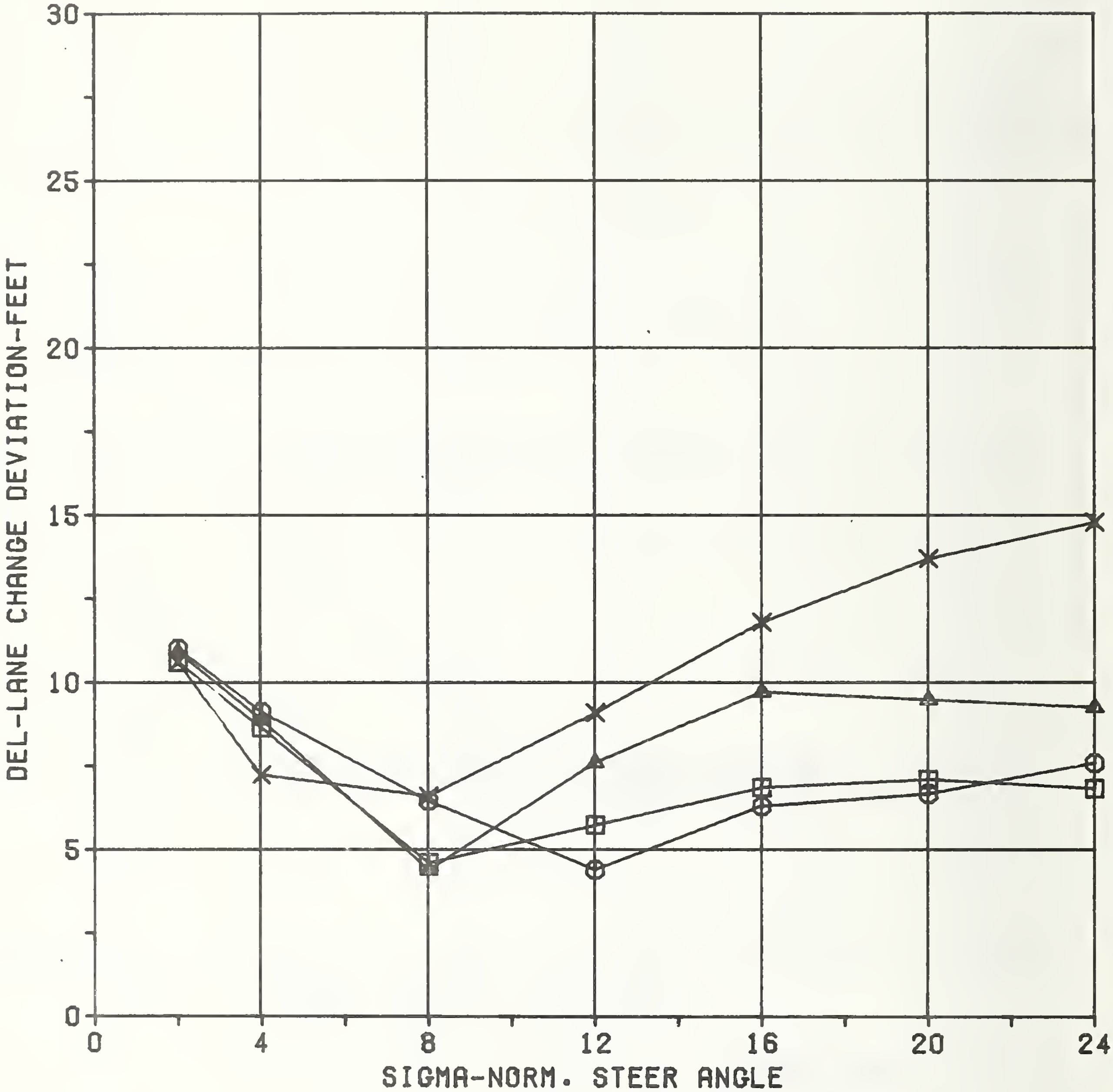
FIG. 14 *** LANE CHANGE DEV. VS. NORM. STEER ANGLE ***

(CALSPAN, O.E. TIRES, SINUSOIDAL STEER-45 MPH)



● - DODGE CORONET

■ - CHEVY BROOKWOOD

▲ - PONTIAC TRANS AM

× - VW SUPERBEETLE

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FIG. 15 *** SIDESLIP ANGLE VS. LANE CHANGE DEV. ***

(CALSPAN, O.E. TIRES, SINUSOIDAL STEER-45 MPH)

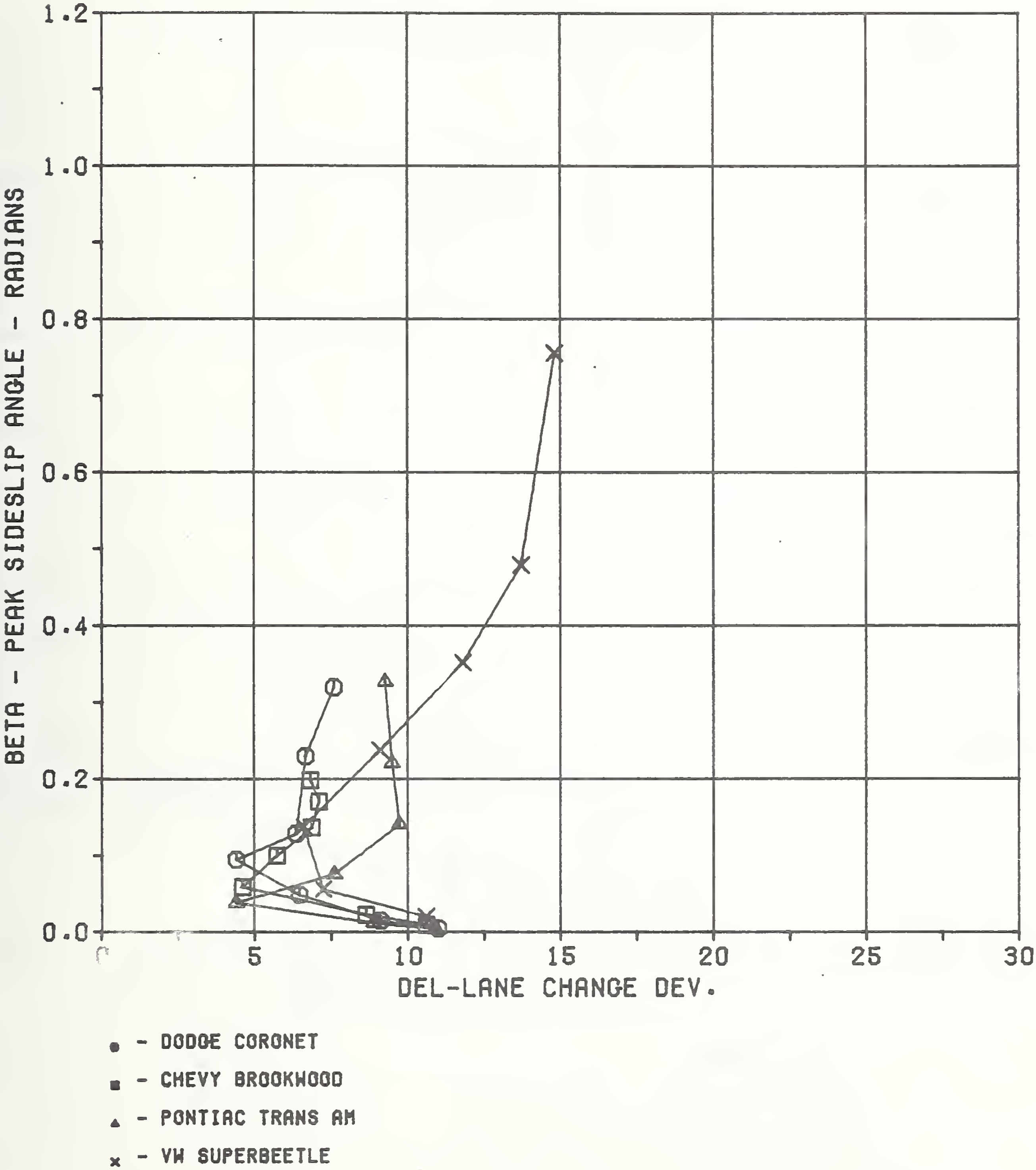

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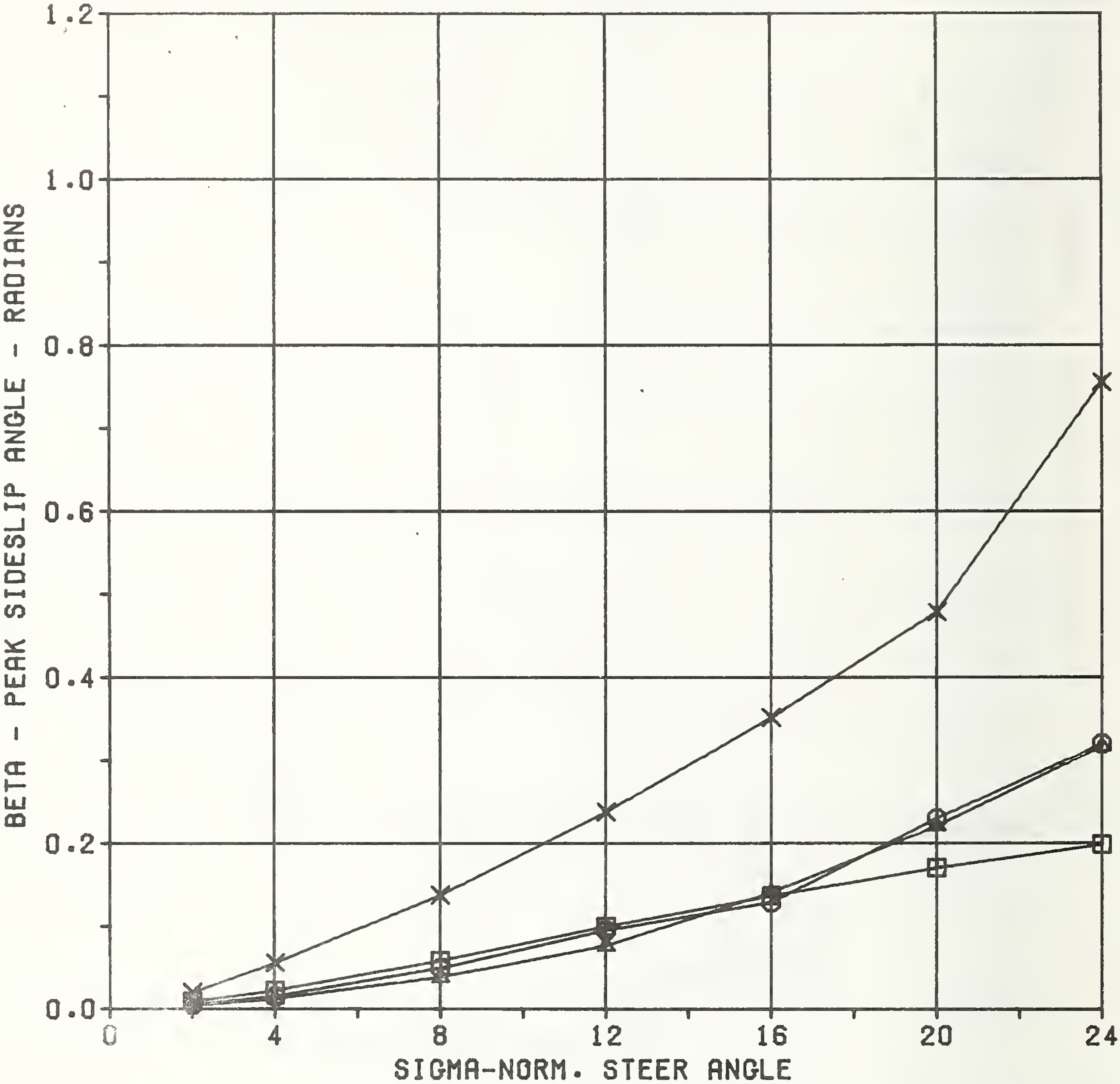
FIG. 16 *** SIDESLIP ANGLE VS. NORM. STEER ANGLE ***

(CALSPAN, O.E. TIRES, SINUSOIDAL STEER-45 MPH)



● - DODGE CORONET

■ - CHEVY BROOKWOOD

▲ - PONTIAC TRANS AM

x - VW SUPERBEETLE

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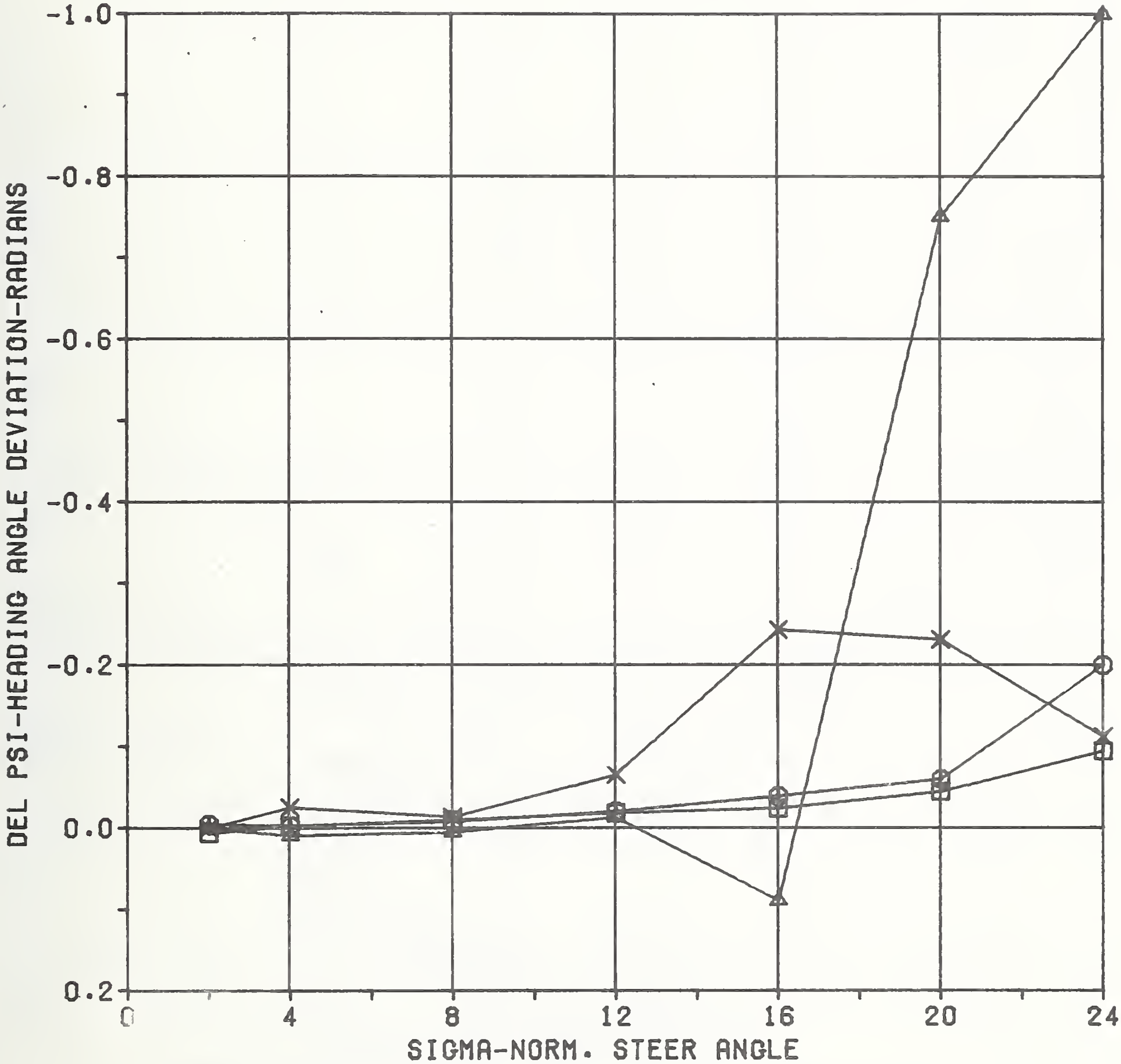
FIG. 17 *** HEADING ANGLE DEV. VS. NORM. STEER ANGLE ***

(CALSPAN, O.E. TIRES, SINUSOIDAL STEER-60 MPH)



● - DODGE CORONET

■ - CHEVY BROOKWOOD

▲ - PONTIAC TRANS AM

× - VW SUPERBEETLE

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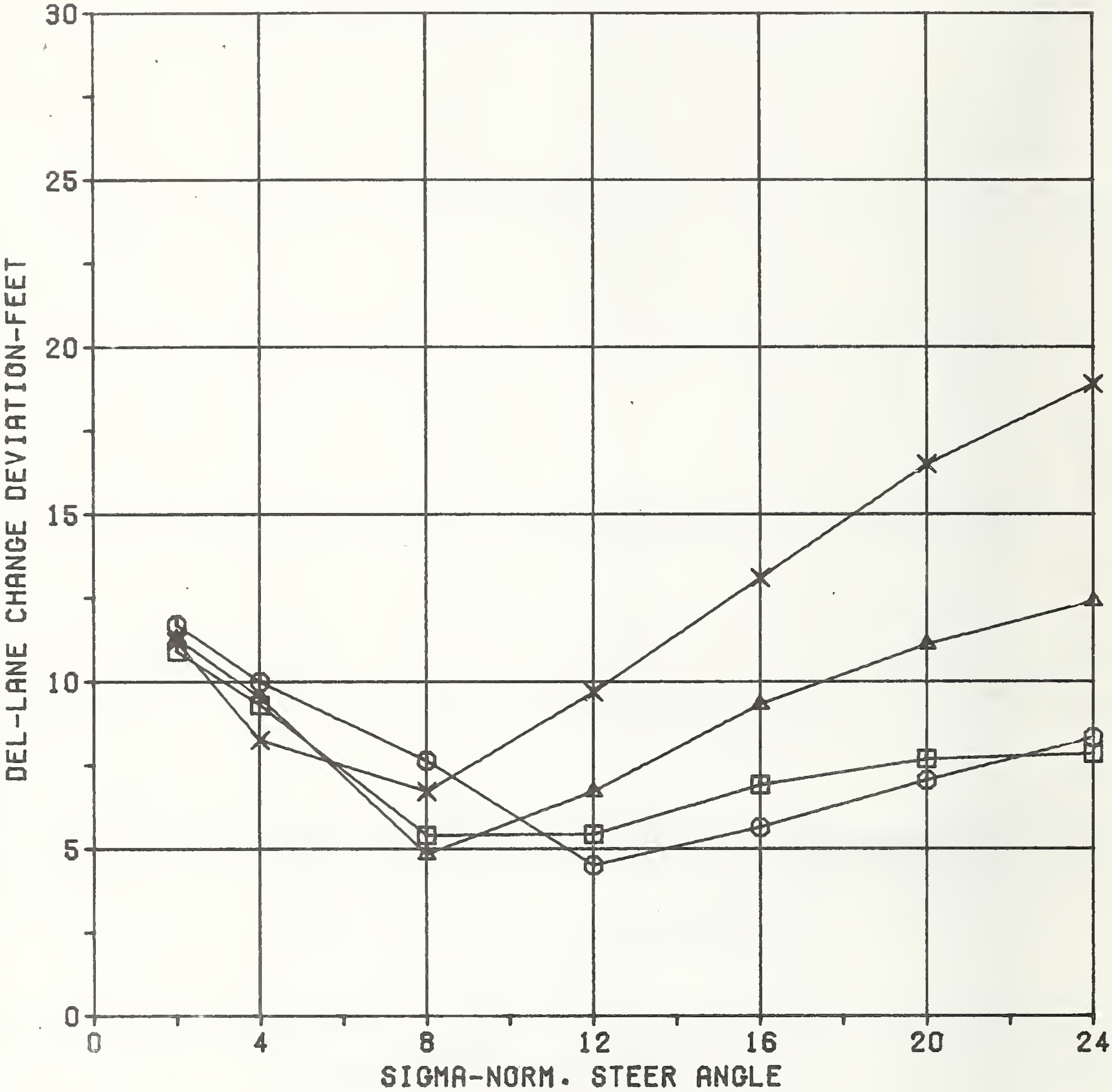
FIG. 18 *** LANE CHANGE DEV. VS. NORM. STEER ANGLE ***

(CALSPAN, O.E. TIRES, SINUSOIDAL STEER-60 MPH)



● - DODGE CORONET

■ - CHEVY BROOKWOOD

▲ - PONTIAC TRANS AM

× - VW SUPERBEETLE

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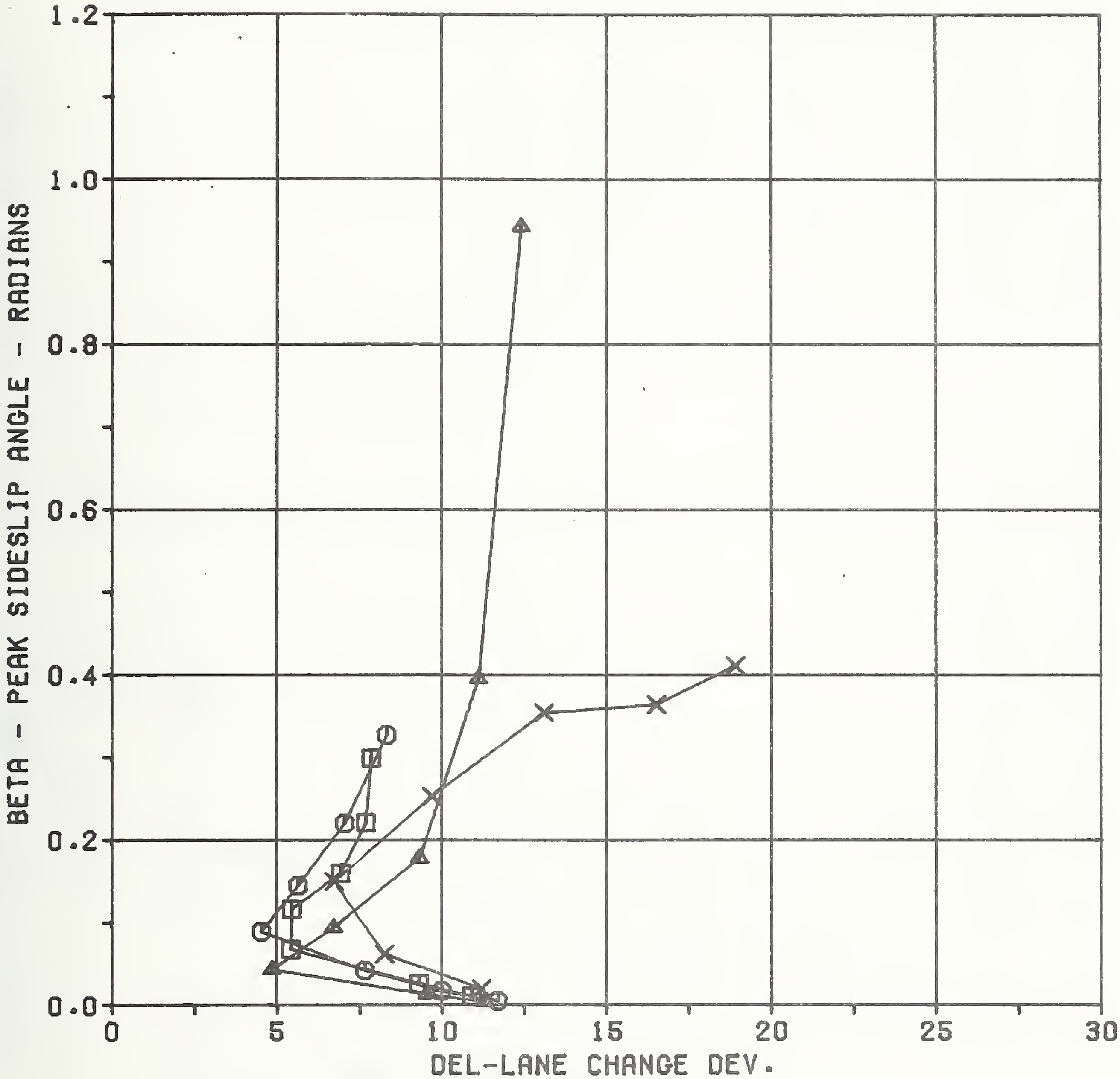
FIG. 19 *** SIDESLIP ANGLE VS. LANE CHANGE DEV. ***

(CALSPAN, O.E. TIRES, SINUSOIDAL STEER-60 MPH)



● - DODGE CORONET

■ - CHEVY BROOKWOOD

▲ - PONTIAC TRANS AM

× - VW SUPERBEETLE

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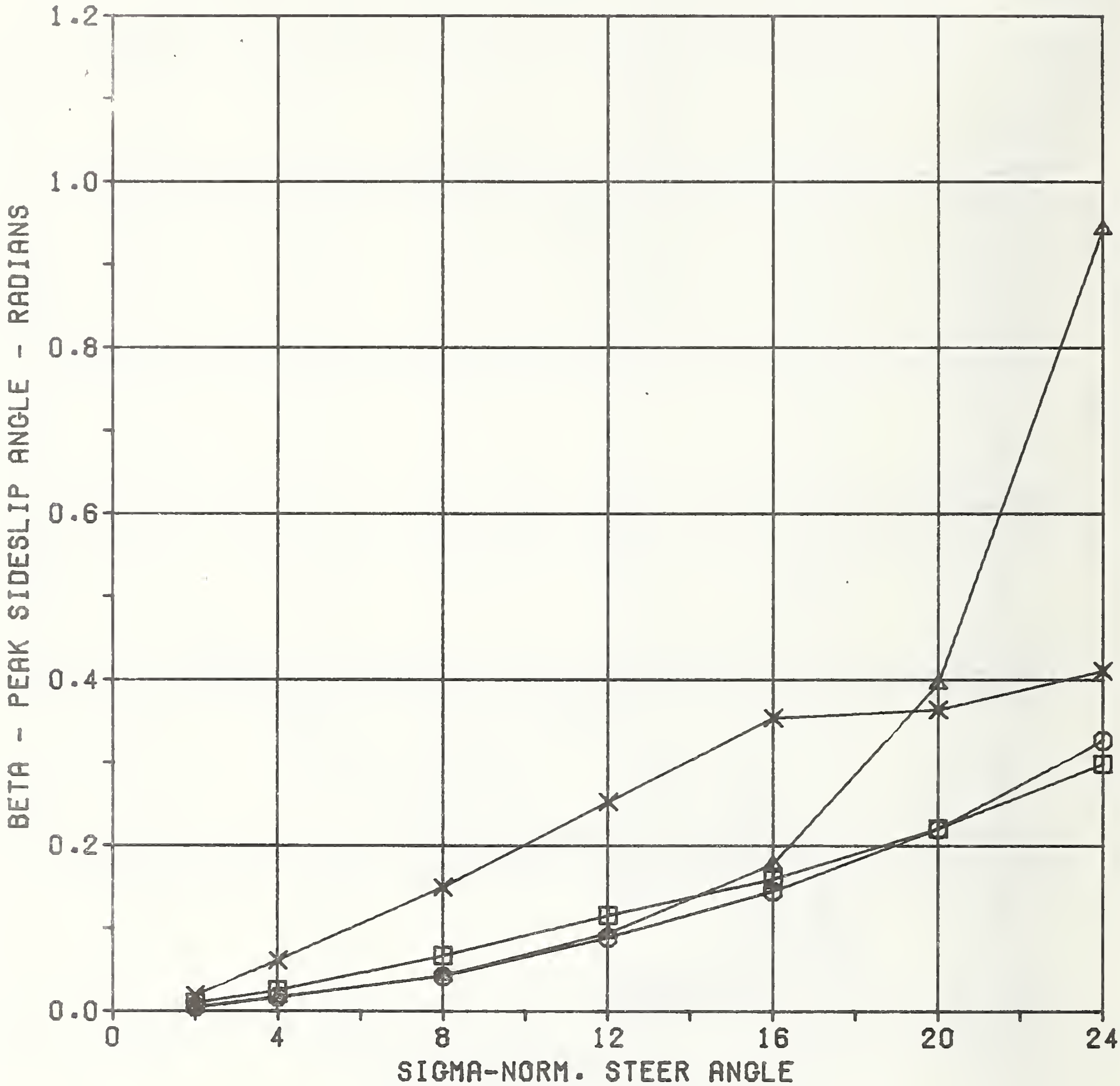
FIG. 20 *** SIDESLIP ANGLE VS. NORM. STEER ANGLE ***

(CALSPAN, O.E. TIRES, SINUSOIDAL STEER-60 MPH)



● - DODGE CORONET

■ - CHEVY BROOKWOOD

▲ - PONTIAC TRANS AM

× - VW SUPERBEETLE

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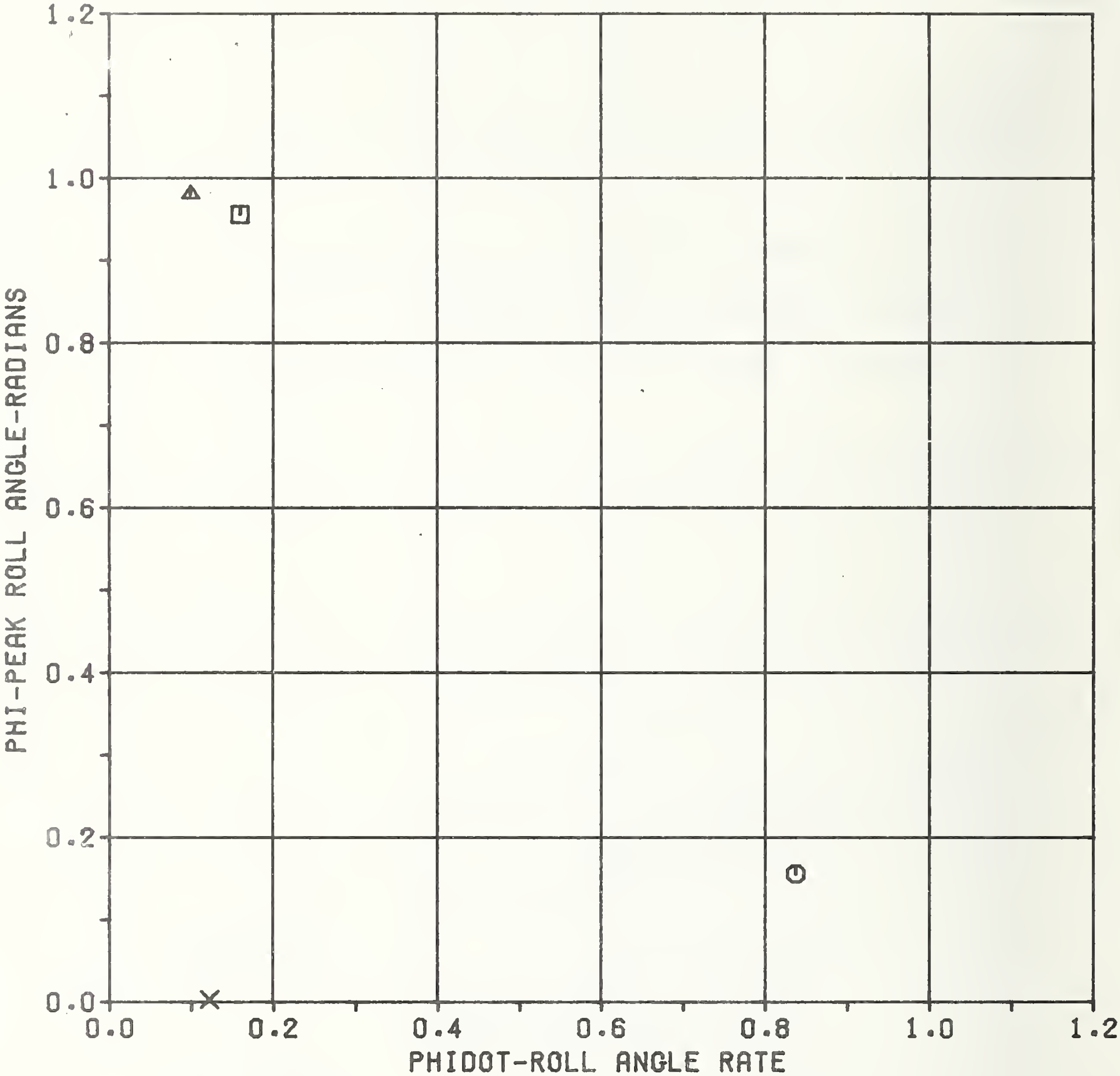
6. VHTP #6 - DRASTIC STEER AND BRAKE

PHI - Peak Roll Angle (RADIANS)

PHIDOT - Peak Roll Angle Rate (RADIANS/SEC)

FIG. 21 *** ROLL ANGLE VS. ROLL ANGLE RATE ***

(CALSPAN, O.E. TIRES, DRASTIC STEER & BRAKE-50 MPH)



• - DODGE CORONET

▪ - CHEVY BROOKWOOD

▲ - PONTIAC TRANS AM

× - VW SUPERBEETLE

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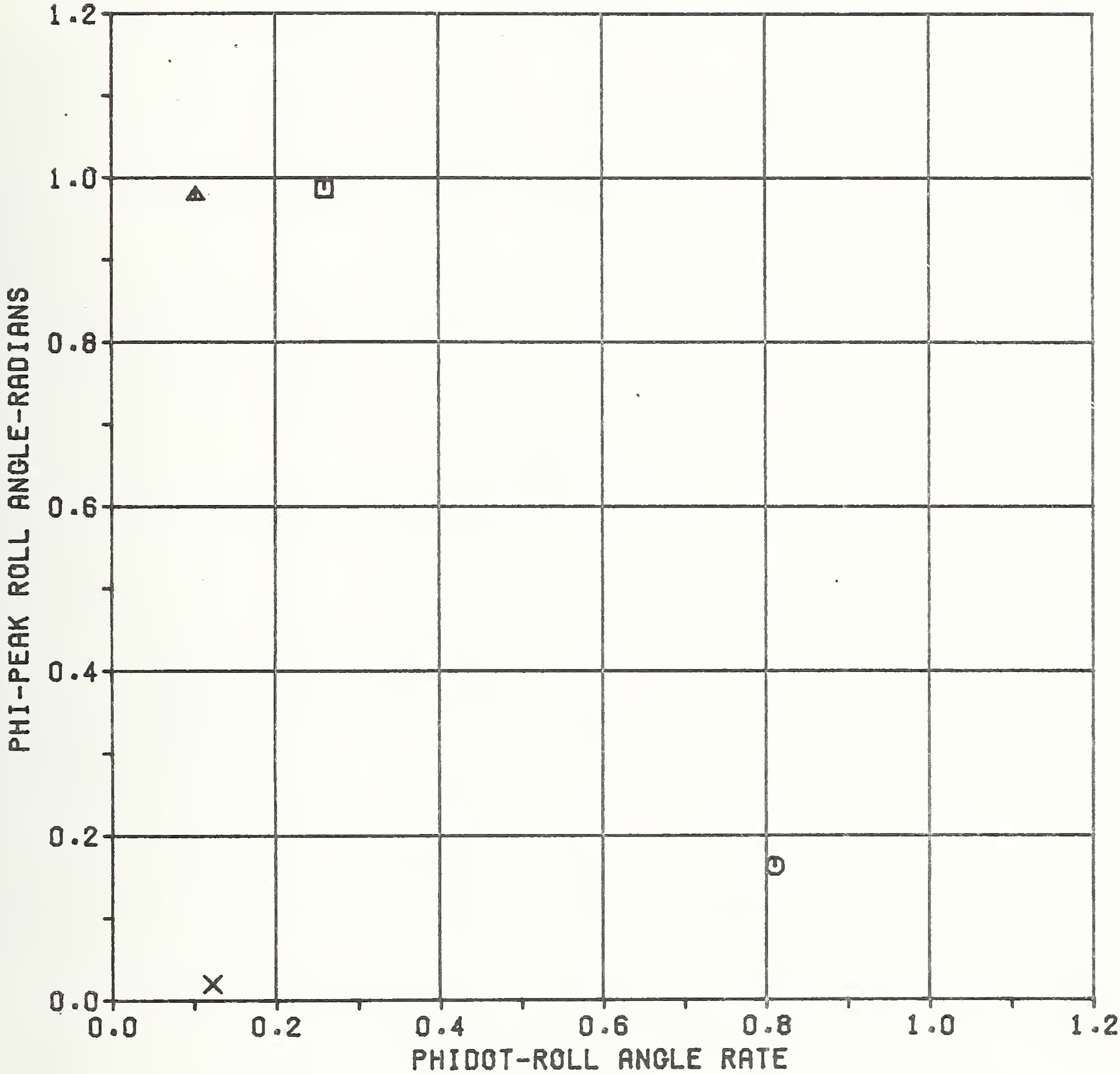
FIG. 22 *** ROLL ANGLE VS. ROLL ANGLE RATE ***

(CALSPAN, O.E. TIRES, DRASTIC STEER & BRAKE-60 MPH)



● - DODGE CORONET

■ - CHEVY BROOKWOOD

▲ - PONTIAC TRANS AM

x - VW SUPERBEETLE

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APPENDIX G

SIMULATION OUTPUT

APPENDIX G
SIMULATION OUTPUT

In addition to the user/computer transactions printed on the hybrid operator's printer, the simulation has several outputs which are normally available to the user. The output is summarized below:

(1) VHTP comparison variable values

(2) analog strip chart time history recordings (sixteen variables)

(3) digital printout of variables versus time (up to fifty variables)

(4) comparison variable graphs.

The appropriate VHTP comparison variable values are printed following the execution of a VHTP maneuver. Typical examples are presented in Figure G-1.

Sixteen channels of strip chart time history recordings are available. Time histories for the braking in a turn test procedure are presented in Figures G-2(a) and G-2(b). The variables are defined below:

Figure G-2(a) -

(1) longitudinal deceleration in gees (A_x),

(2) lateral acceleration in gees (A_y),

(3) vehicle yaw rate in radians per second (r),

(4) steering wheel input in radians (δ_{sw}),

(5) vehicle forward velocity in feet per second (u),

(6) vehicle side velocity in feet per second (v),

(7) vehicle sideslip angle in radians (β), and

(8) turning radius of curvature in feet^{-1}, (1/R).

Figure G-2(b) -

(1-4) the angular velocities of the right front, left front, right rear, and left rear wheels in radians per second (ω_1, ω_2, ω_3, ω_4, respectively);

(5-7) the deflection from the equilibrium position of the right front wheel, left front wheel, and rear axle in inches (δ_1, δ_2, δ_R, respectively);

(8) the angular rotation of the rear axle with reference to the sprung mass in radians (ϕ_R).

The digital printout of variables versus time is the typical output associated with digital simulation. The variables to be output can be specified in the program data deck or selected interactively during program execution. The time interval for output is also interactively selected. The interactive selection capability is particularly useful for

simulation validation or studying unexpected dynamic phenomena. Any variable within the simulation can be selected for output. An output example is presented in Figure G-3.

To aid in quick analysis of vehicle performance, computer generated comparison variable plots are made available. An example plot for a trapezoidal steer test procedure is presented in Figure G-4.

```
**********    THIS IS THE FIRST OF TWO SPECIAL CARDS FOR THE 2741 ACM  *********
        VEHICLE HANDLING SIMULATION
ENGAGE PATCH PANEL FOR TEST
TYPE CR WHEN READY
****
MAY        21  1974
TIME  14: 0:11.76
OPTION
****  F
ENTER
****  VHTPNO 4
****
OPTION
****  IC
OPTION
****  F
ENTER
****  STR4
   27.90
****  STR4 300.
****
OPTION
****  X
MAY        21  1974
TIME  14: 2: 7.18
RUN   1 HAS STARTED
OUTPUT BELOW
 AXAV=   0.0   DECL TIME=   0.000 AVCUR=   0.981 BTDMAX=   0.210 RTMAX=   0.126 DELBT=   0.126
AYMAX=   0.945 PHIMAX=   4.101 RMAX=   0.708 LANE CHNG DEL=   0.0   DELPSI=   0.0   MAX STEER= 300.000
LTRQMAX=   0.0   RTRQMAX=   0.0

OPTION
****  F
ENTER
****  VHTPNO
   4.000
****
OPTION
****  MULTI
NUM OF LOOPS,VARS
****  4 1
VAR
****  STR4
LOOP,VAL,INC
****  1 27.9 27.9
****
OPTION
****  XM
MAY        21  1974
TIME  14: 4:16.24
RUN   2 HAS STARTED
OUTPUT BELOW
MULTI TOTAL STR4..(   1) BETAMX(   1) BETDMX(   1) CUVRAT(   1) AYMAX.(   1) RMAX..(   1)
  1     2       27.9       0.315E-02    0.208E-01    0.928E-01    0.134       0.694E-01
  2     3       55.8       0.105E-01    0.341E-01    0.260        0.342       0.186
  3     4       83.7       0.219E-01    0.646E-01    0.428        0.539       0.304
  4     5       112.       0.375E-01    0.909E-01    0.573        0.691       0.409
OPTION
```

Fig. G-1 HVHP USER'S INTERACTIVE CONTROL

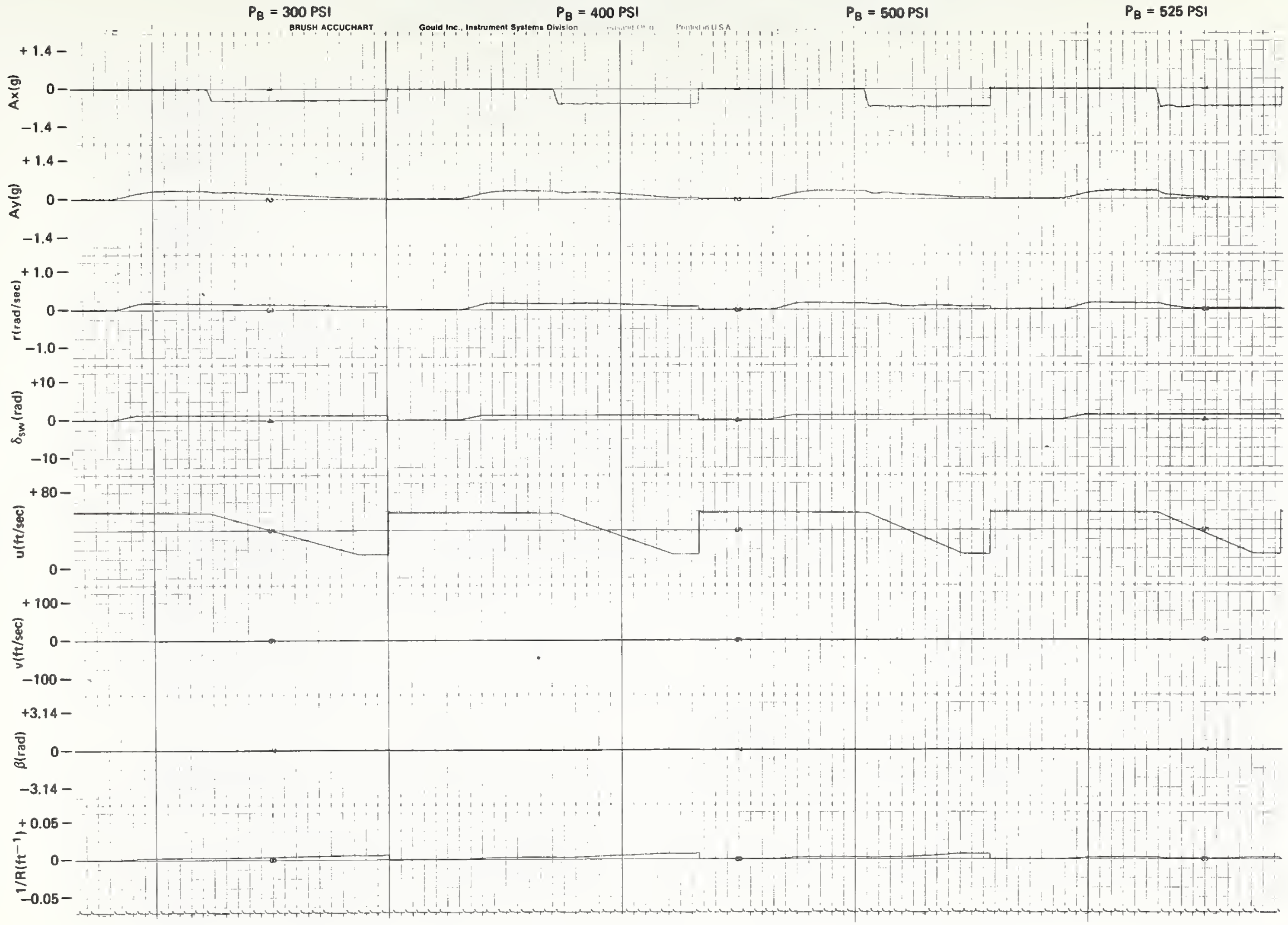

Fig. G-2(a) TIME HISTORIES - BRAKING IN A TURN

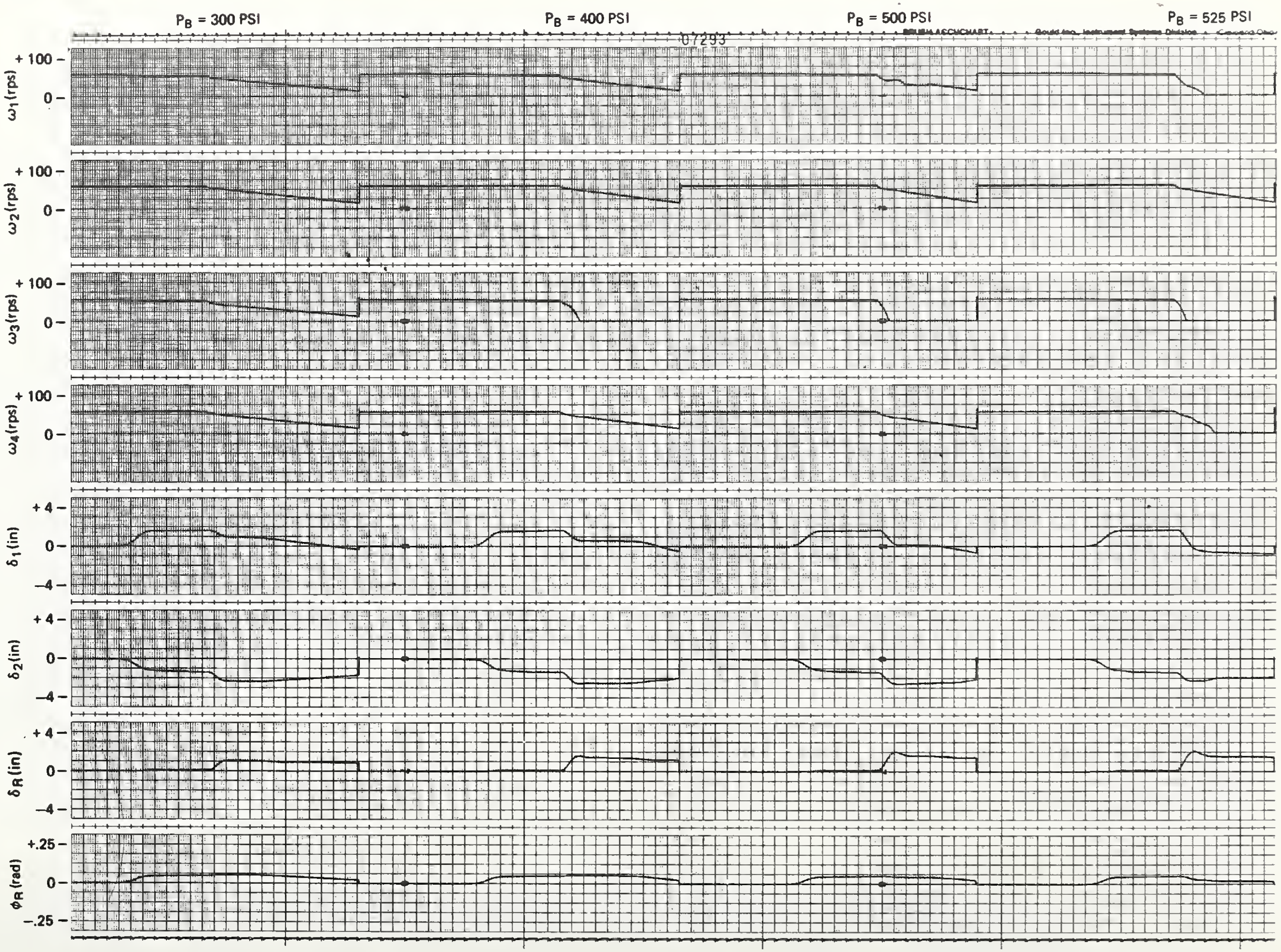

Fig. G-2(b) TIME HISTORIES - BRAKING IN A TURN

```
OPTION
****  TRACK
UNIT,MODE
****  T A
ENTER TIME ON,OFF,STEP
****  .5 1.1 .1
TYPE RETAIN OR ENTER NEW ARRAY
****  PSIDT PHIDT PHI ZIMX(1) ZIMX(3)
****
```

TIME	PSIDT.(1)	PHIDT.(1)	PHI...(1)	ZIMX..(1)	ZIMX..(3)
0.50	0.43077	0.77597E-02	-0.11728	0.29986E-01	0.10125
0.60	0.35703	0.29683	-0.10414	0.29986E-01	0.10125
0.70	0.28586	0.49151	-0.59047E-01	0.29986E-01	0.10125
0.80	0.28740	0.32454	-0.16426E-01	0.29986E-01	0.10125
0.90	0.30123	0.14344E-02	-0.12279E-03	0.29986E-01	0.10125
1.00	0.28316	-0.14820	-0.90558E-02	0.29986E-01	0.10125
1.10	0.29048	-0.38197	-0.30314E-01	0.29986E-01	0.10125

OPTION

Fig. G-3 DIGITAL LINE PRINTER OUTPUT

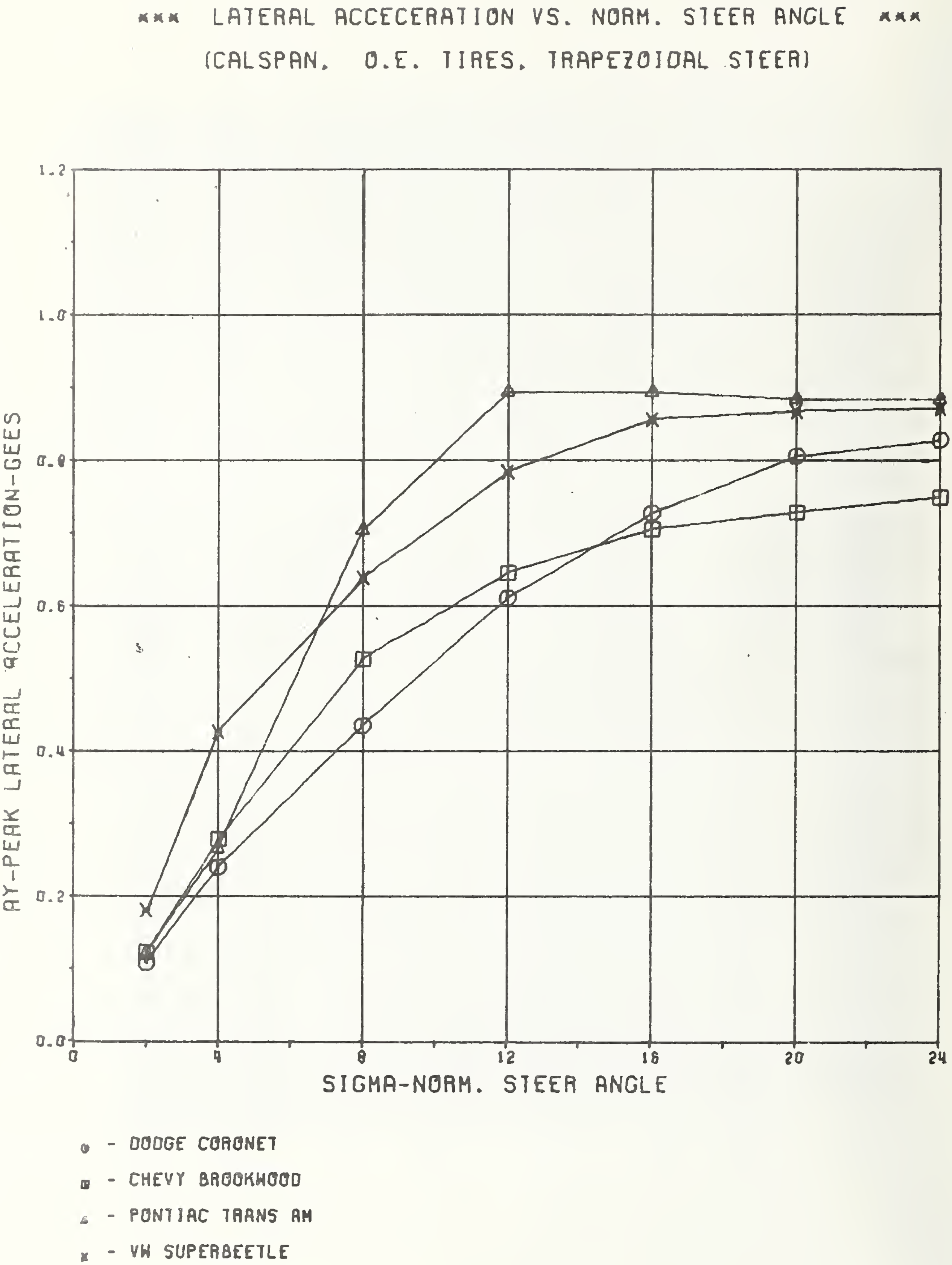

Fig. G-4 COMPARISON VARIABLE PLOT

APPENDIX H

TIRE FUNCTION GRAPHS

1. PRESENTED HERE ARE GRAPHS USED TO VALIDATE THE TIRE MODEL OUTPUT FOR A SET OF TIRE PARAMETERS

FIG. 1 SIDE FORCE VS. SLIP ANGLE WITH NORMAL LOAD VARYING

(F78X14 GY BB CPCP CAMBER=0., SLIP=0.)

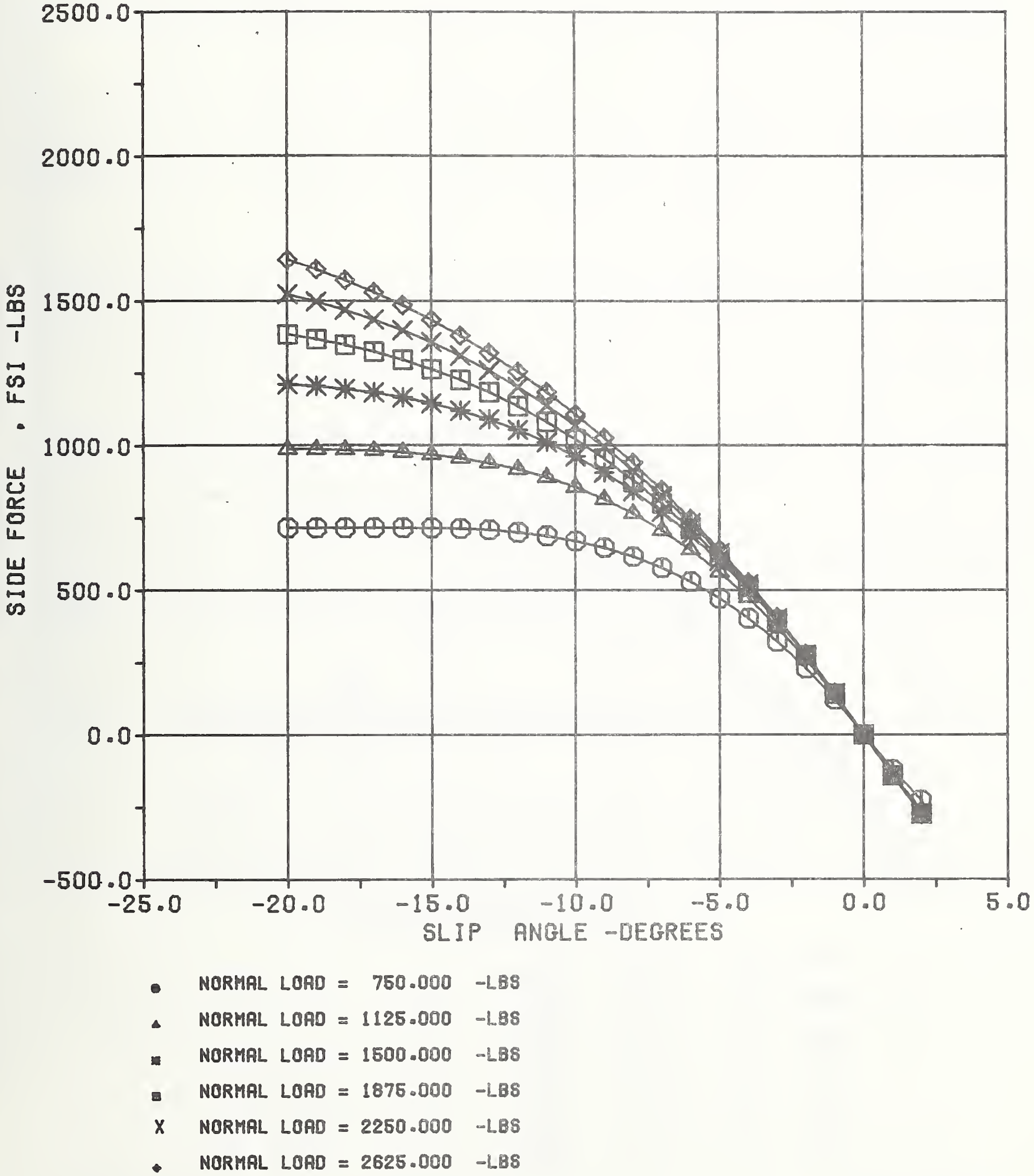

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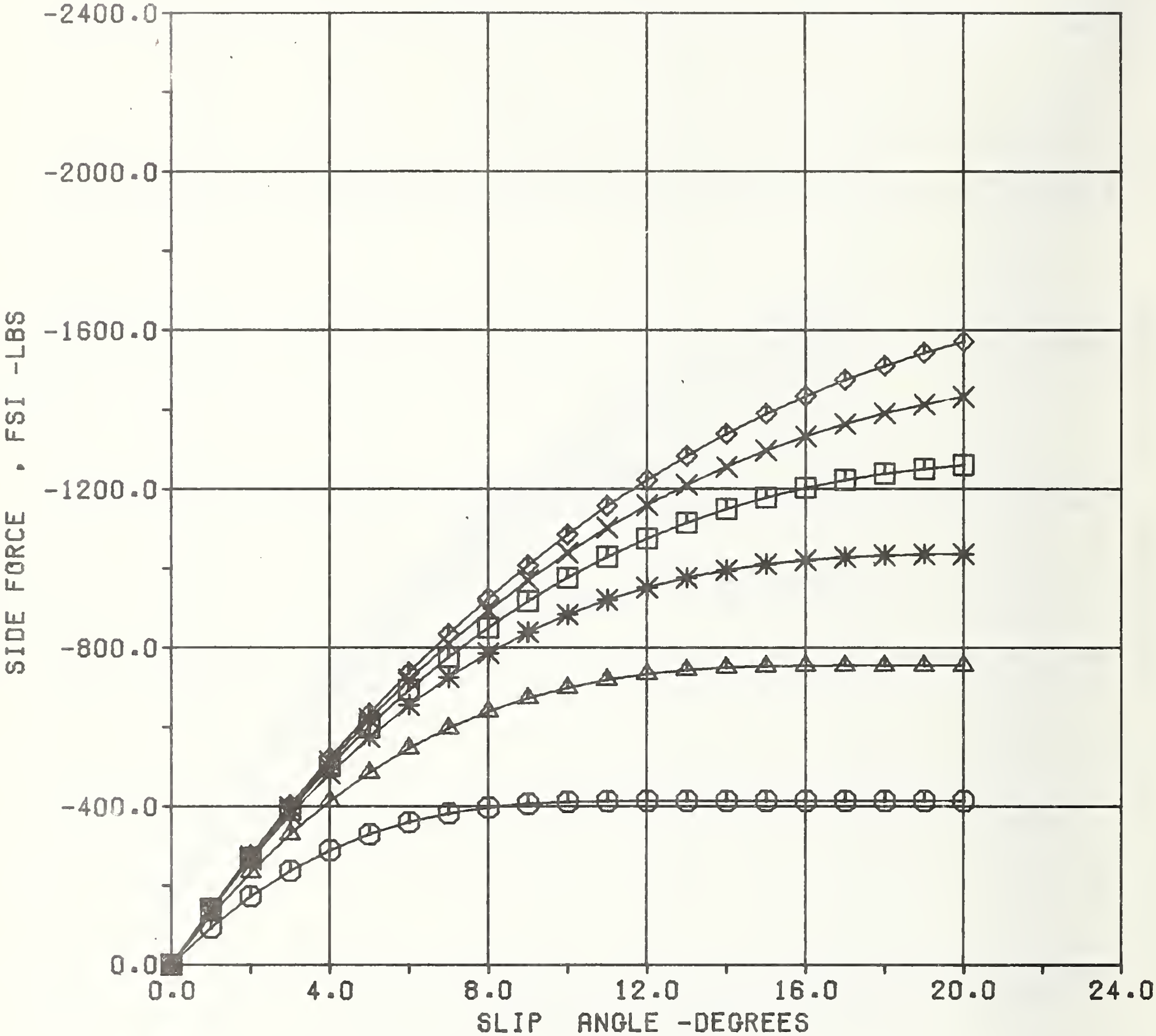
FIG. 2 SIDE FORCE VS. SLIP ANGLE WITH NORMAL LOAD VARYING

(F78X14 GY BB CPCP CAMBER=0., SLIP=0.)



NORMAL LOAD = 400.000 -LBS

NORMAL LOAD = 800.000 -LBS

NORMAL LOAD = 1200.000 -LBS

NORMAL LOAD = 1600.000 -LBS

X NORMAL LOAD = 2000.000 -LBS

NORMAL LOAD = 2400.000 -LBS

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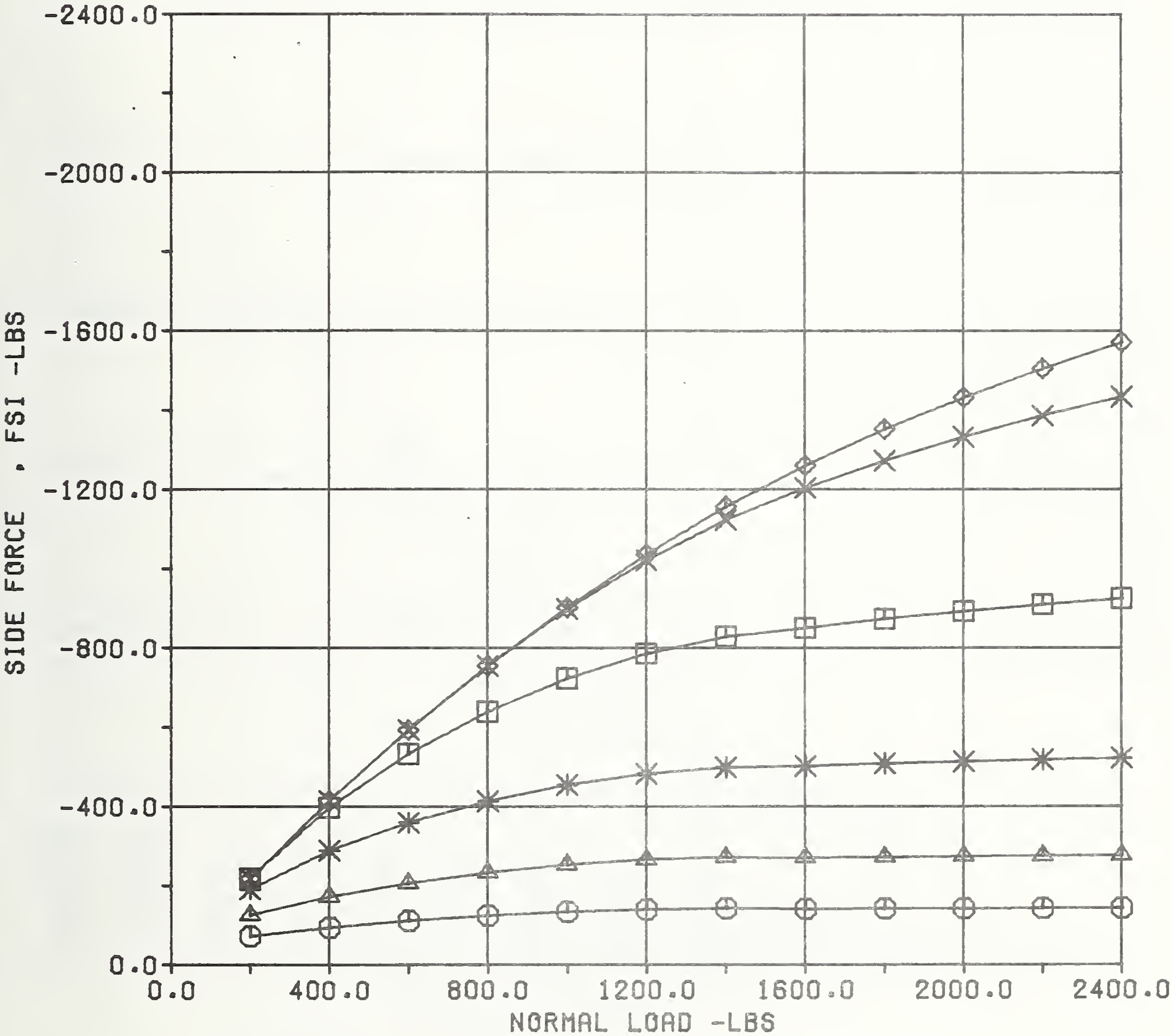
FIG. 1 SIDE FORCE VS. NORMAL LOAD WITH SLIP ANGLE VARYING

(F78X14 GY BB CPCP CAMBER=0., SLIP=0.)



● SLIP ANGLE = 1.000 -DEGREES
▲ SLIP ANGLE = 2.000 -DEGREES
✱ SLIP ANGLE = 4.000 -DEGREES
■ SLIP ANGLE = 8.000 -DEGREES
X SLIP ANGLE = 16.000 -DEGREES
◆ SLIP ANGLE = 20.000 -DEGREES

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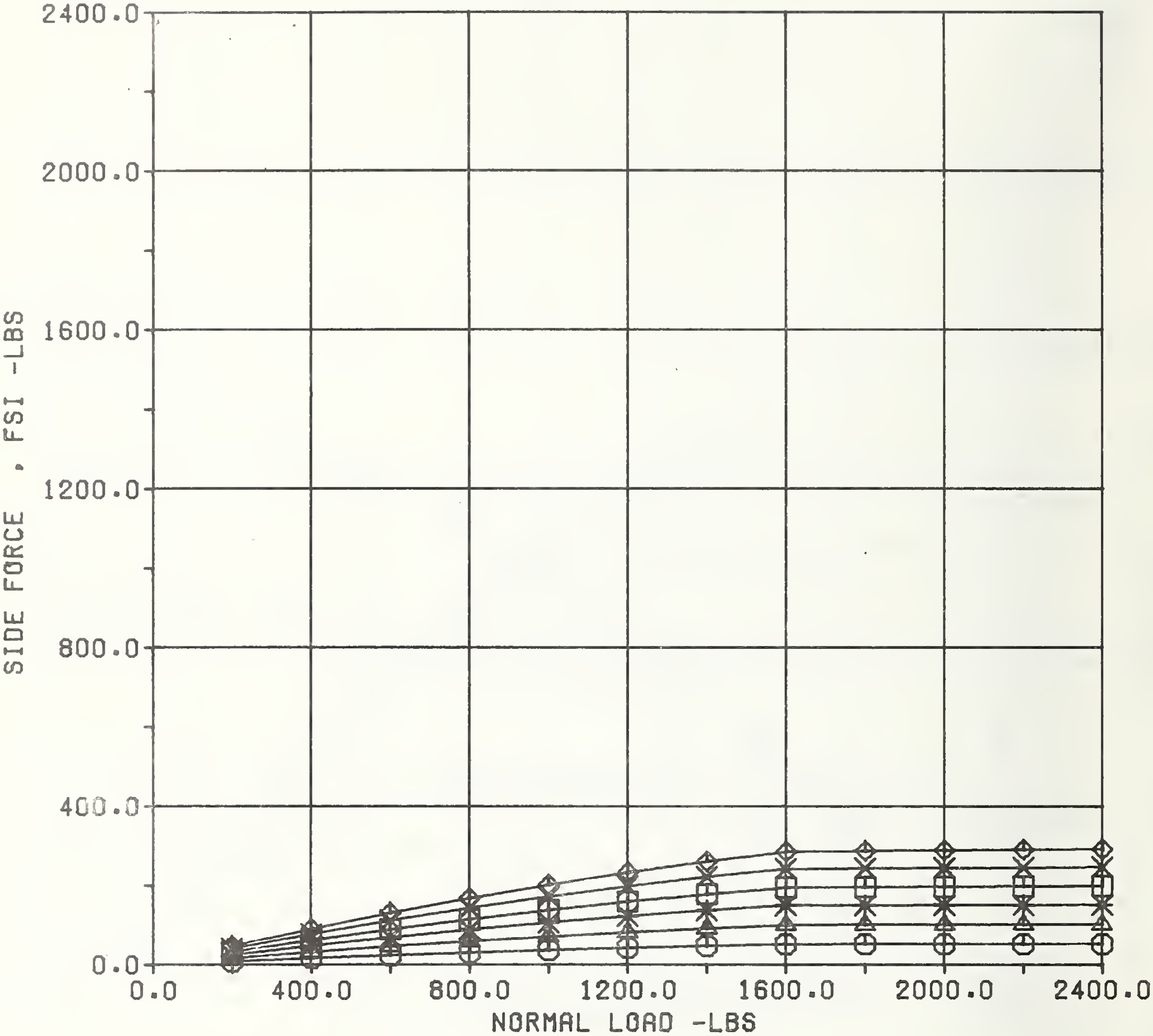
FIG. 2 SIDE FORCE VS. NORMAL LOAD WITH CAMBER ANGLE VARYING

(F78X14 GY BB CPCP SLIP ANGLE=0., SLIP=0.)



- CAMBER ANGLE= 2.000 -DEGREES
- CAMBER ANGLE= 4.000 -DEGREES
- CAMBER ANGLE= 6.000 -DEGREES
- CAMBER ANGLE= 8.000 -DEGREES
- X CAMBER ANGLE= 10.000 -DEGREES
- CAMBER ANGLE= 12.000 -DEGREES

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FIG. 3 SIDE FORCE VS. SLIP WITH NORMAL LOAD VARYING

(F78X14 GY BB CPCP SLIP ANGLE=8., CAMBER=0.)

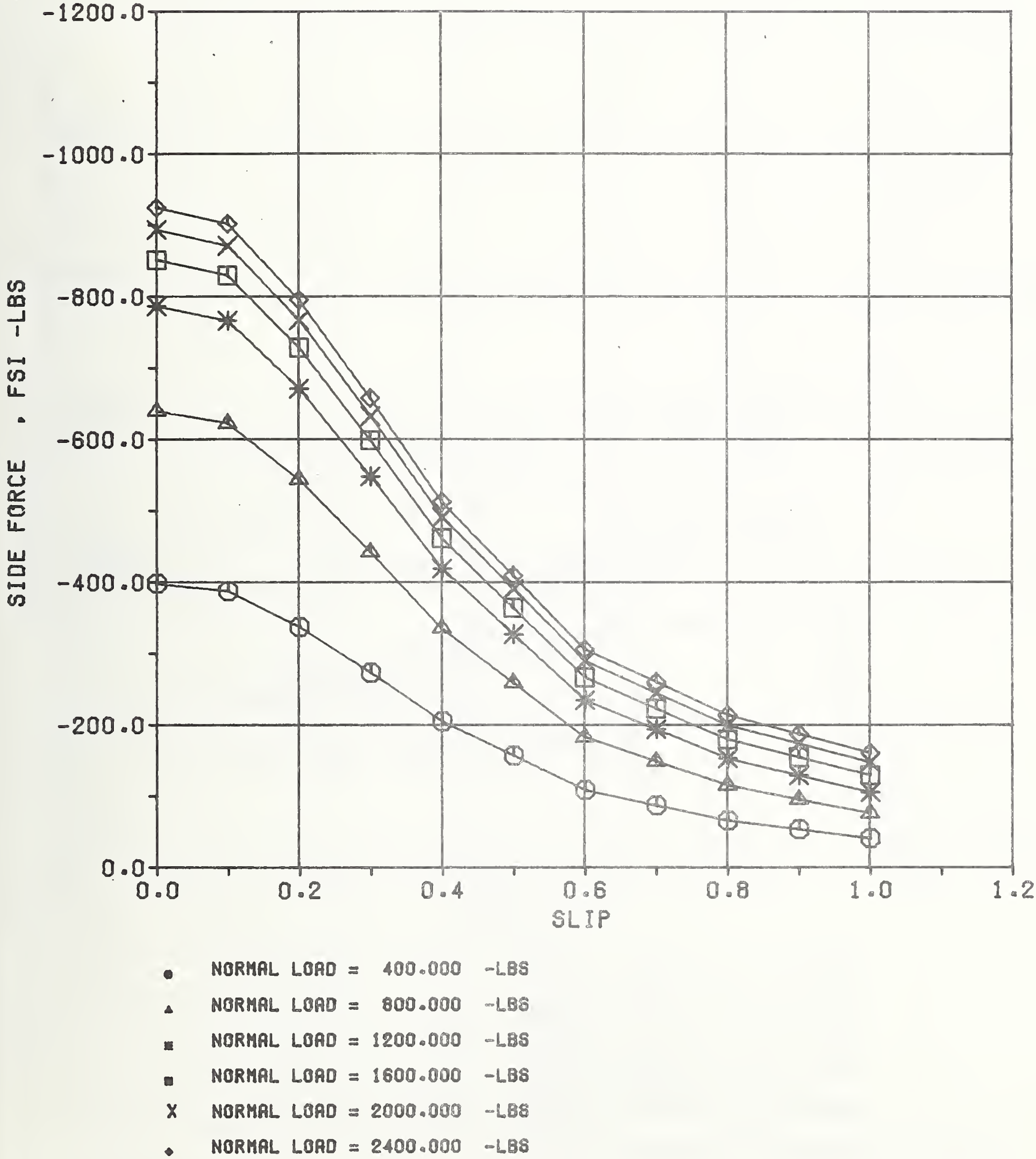

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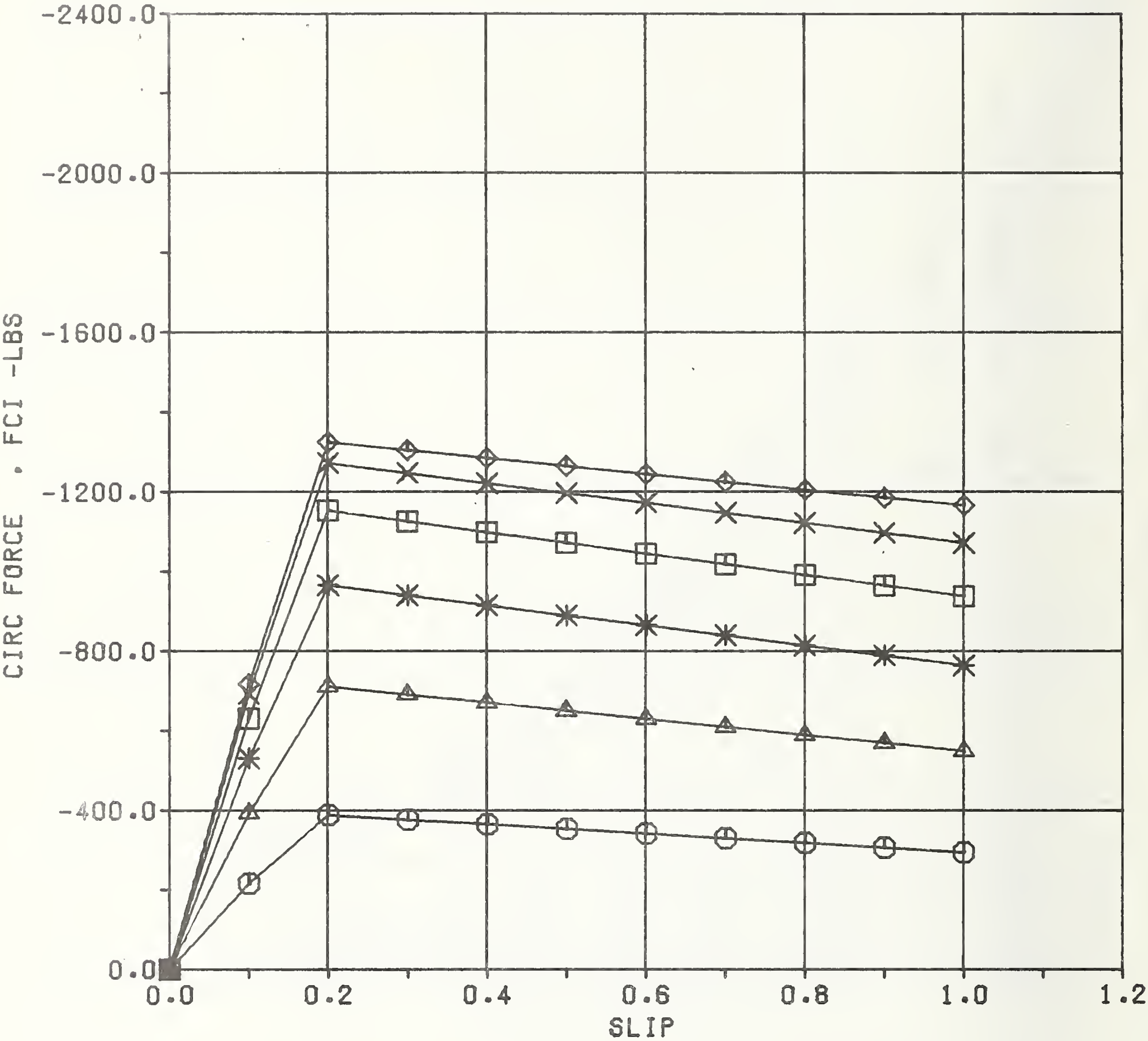
FIG. 4 CIRC FORCE VS. SLIP WITH NORMAL LOAD VARYING

(F78X14 GY BB CPCP SLIP ANGLE=0., CAMBER=0.)



NORMAL LOAD = 400.000 -LBS
NORMAL LOAD = 800.000 -LBS
NORMAL LOAD = 1200.000 -LBS
NORMAL LOAD = 1600.000 -LBS
X NORMAL LOAD = 2000.000 -LBS
NORMAL LOAD = 2400.000 -LBS

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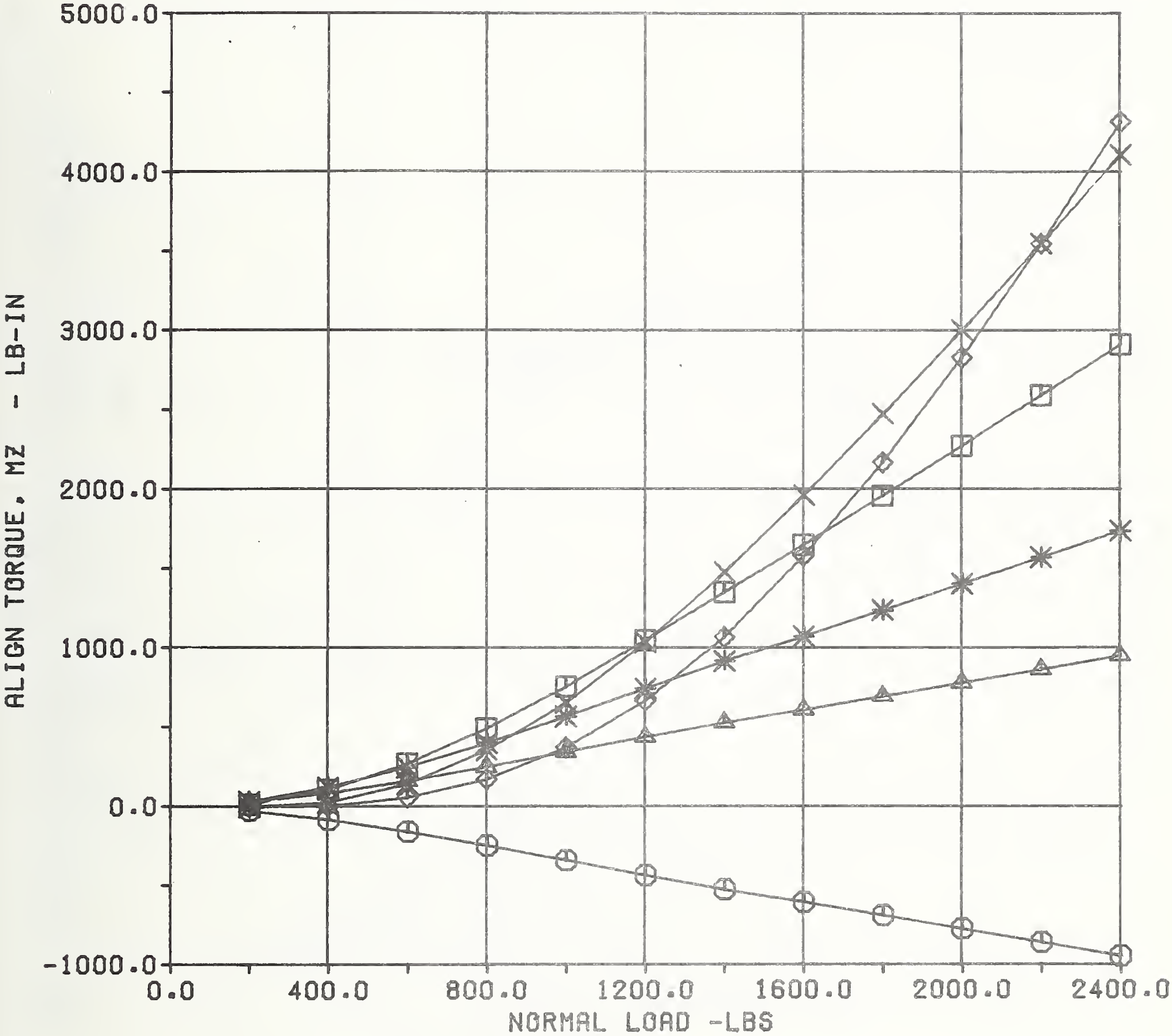
FIG. 5 ALIGN TORQUE VS. NORMAL LOAD WITH SLIP ANGLE VARYING

(F78X14 GY BB CPCP CAMBER=0., SLIP=0.)



●	SLIP ANGLE = -1.000	-DEGREES
▲	SLIP ANGLE = 1.000	-DEGREES
✱	SLIP ANGLE = 2.000	-DEGREES
■	SLIP ANGLE = 4.000	-DEGREES
X	SLIP ANGLE = 8.000	-DEGREES
◆	SLIP ANGLE = 16.000	-DEGREES

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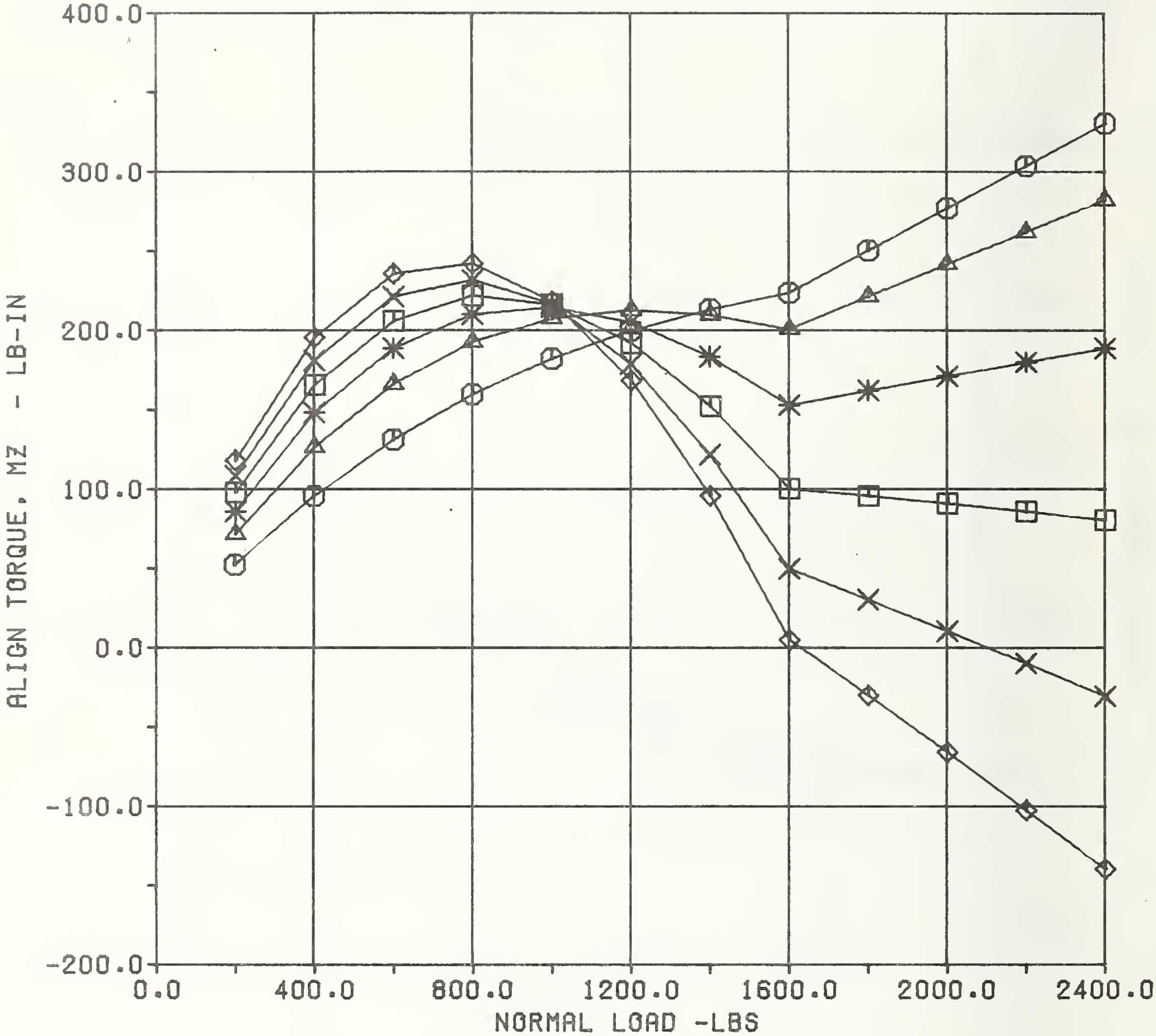
FIG. 6 ALIGN TORQUE VS. NORMAL LOAD WITH CAMBER ANGLE VARYING

(F78X14 GY BB CPCP SLIP ANGLE=0., SLIP=0.)



● CAMBER ANGLE= 2.000 -DEGREES
▲ CAMBER ANGLE= 4.000 -DEGREES
✱ CAMBER ANGLE= 6.000 -DEGREES
■ CAMBER ANGLE= 8.000 -DEGREES
X CAMBER ANGLE= 10.000 -DEGREES
◆ CAMBER ANGLE= 12.000 -DEGREES

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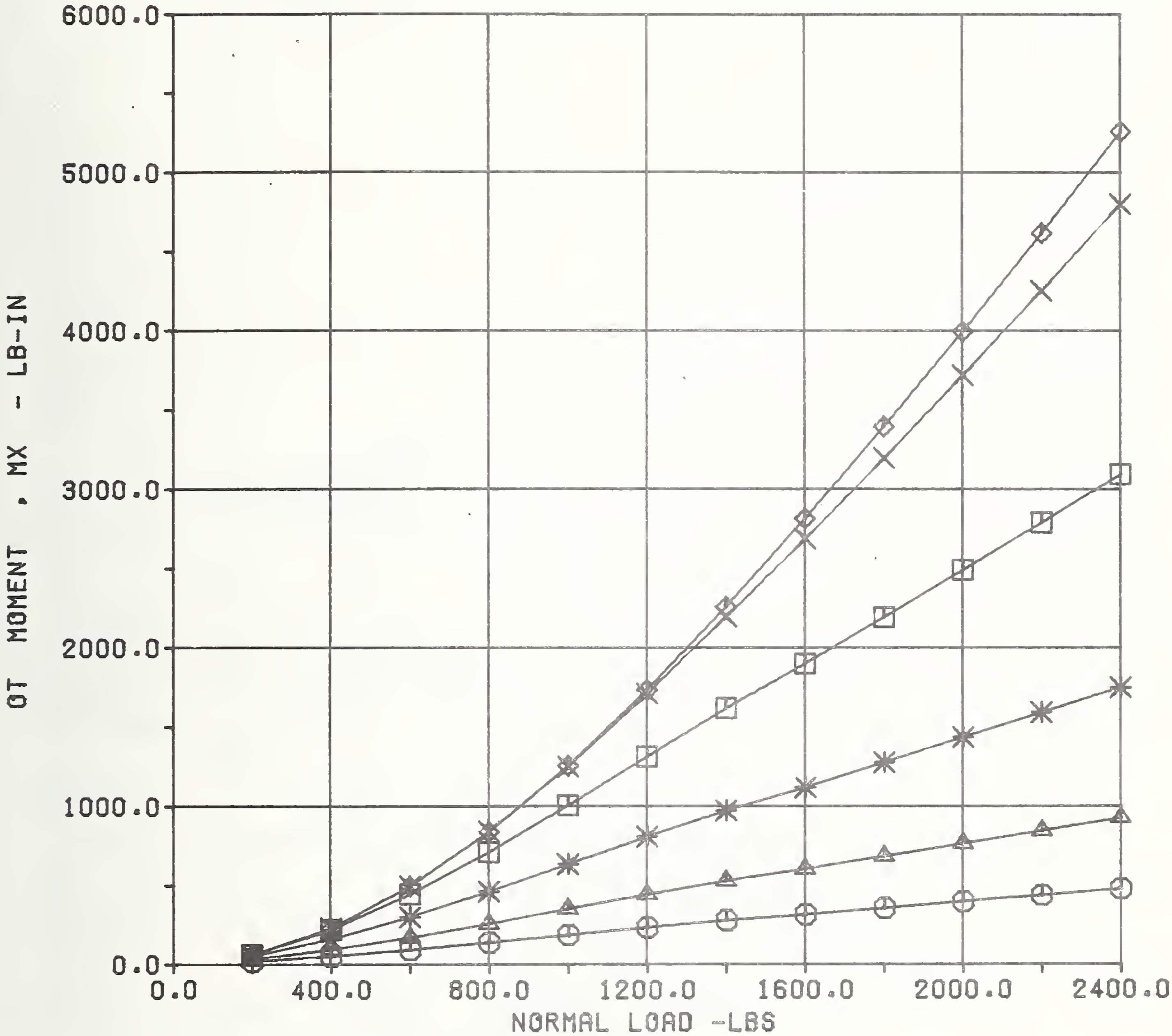
FIG. 7 OT MOMENT VS. NORMAL LOAD WITH SLIP ANGLE VARYING

(F78X14 GY BB CPCP CAMBER=0., SLIP=0.)



● SLIP ANGLE = 1.000 -DEGREES
▲ SLIP ANGLE = 2.000 -DEGREES
✱ SLIP ANGLE = 4.000 -DEGREES
■ SLIP ANGLE = 8.000 -DEGREES
X SLIP ANGLE = 16.000 -DEGREES
◆ SLIP ANGLE = 20.000 -DEGREES

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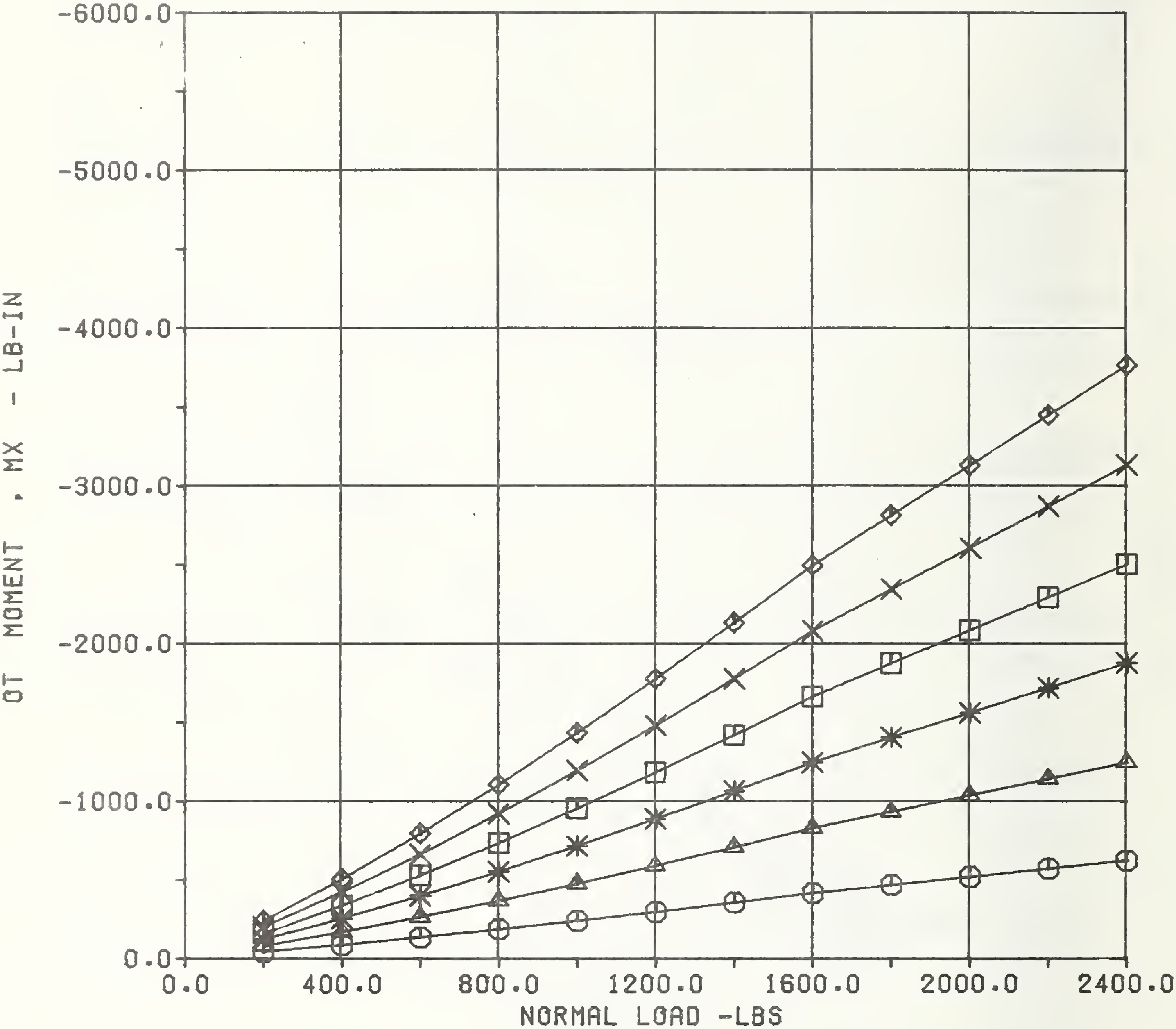
FIG. 8 OT MOMENT VS. NORMAL LOAD WITH CAMBER ANGLE VARYING

(F78X14 GY BB CPCP SLIP ANGLE=0., CAMBER=0.)



CAMBER ANGLE= 2.000 -DEGREES
CAMBER ANGLE= 4.000 -DEGREES
CAMBER ANGLE= 6.000 -DEGREES
CAMBER ANGLE= 8.000 -DEGREES
X CAMBER ANGLE= 10.000 -DEGREES
CAMBER ANGLE= 12.000 -DEGREES

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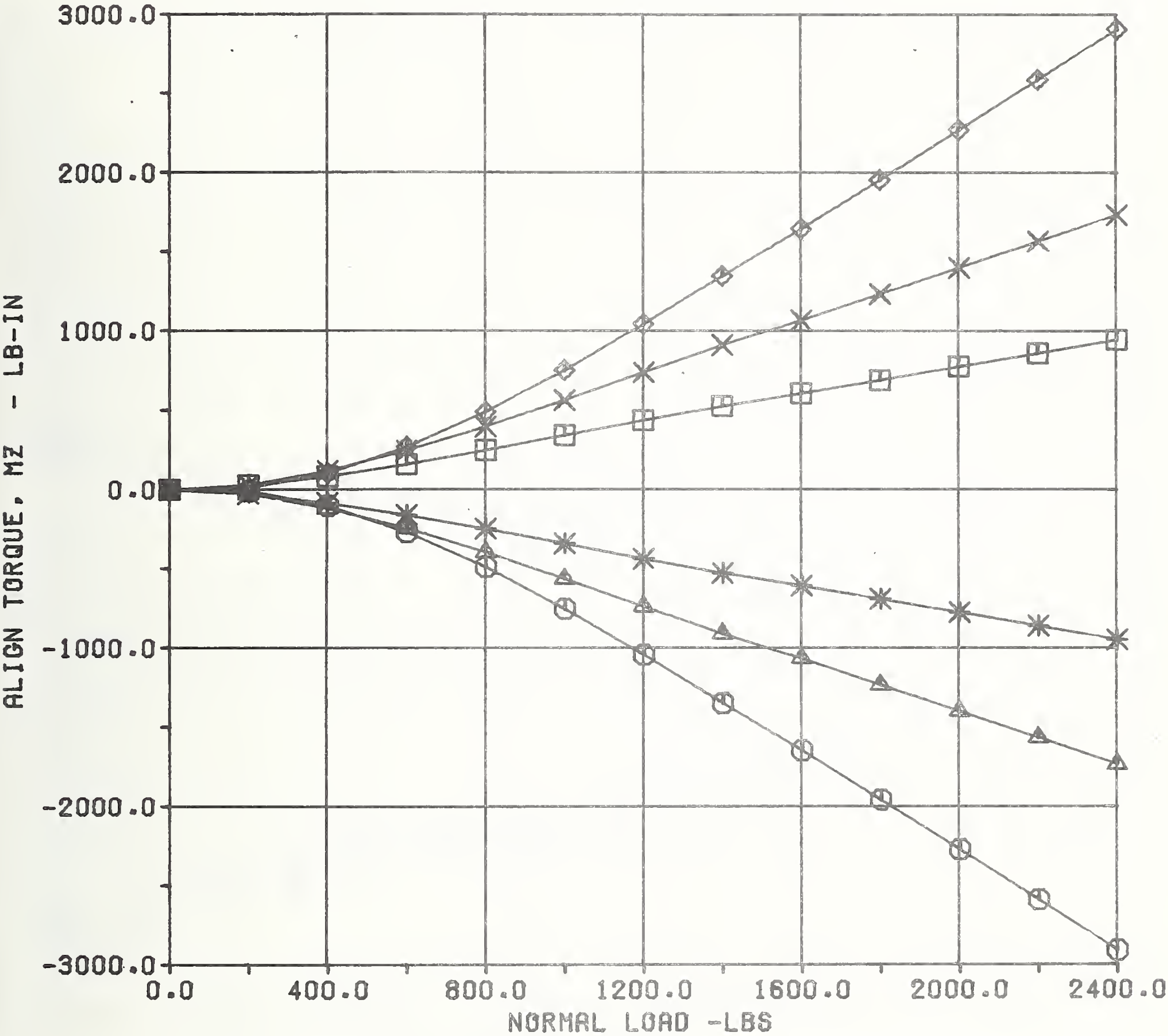
FIG. 9 ALIGN TORQUE VS. NORMAL LOAD WITH SLIP ANGLE VARYING

(F78X14 GY BB CPCP CAMBER=0., SLIP=0.)



- SLIP ANGLE = -4.000 -DEGREES
- SLIP ANGLE = -2.000 -DEGREES
- SLIP ANGLE = -1.000 -DEGREES
- SLIP ANGLE = 1.000 -DEGREES
- X SLIP ANGLE = 2.000 -DEGREES
- SLIP ANGLE = 4.000 -DEGREES

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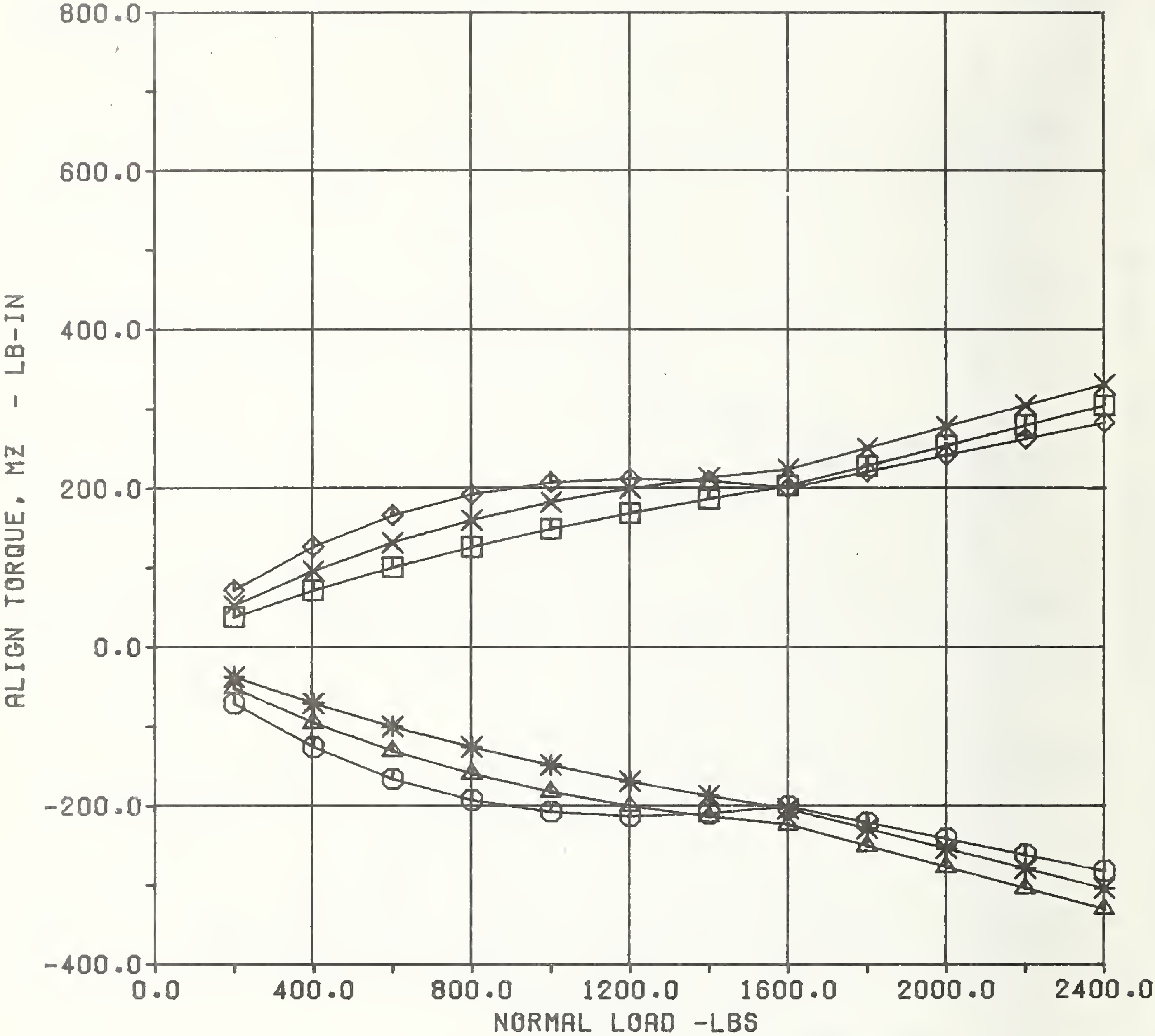
FIG. 10 ALIGN TORQUE VS. NORMAL LOAD WITH CAMBER ANGLE VARYING

(F78X14 GY BB CPCP SLIP ANGLE=0., SLIP=0.)



CAMBER ANGLE= -4.000 -DEGREES

CAMBER ANGLE= -2.000 -DEGREES

CAMBER ANGLE= -1.000 -DEGREES

CAMBER ANGLE= 1.000 -DEGREES

X CAMBER ANGLE= 2.000 -DEGREES

CAMBER ANGLE= 4.000 -DEGREES

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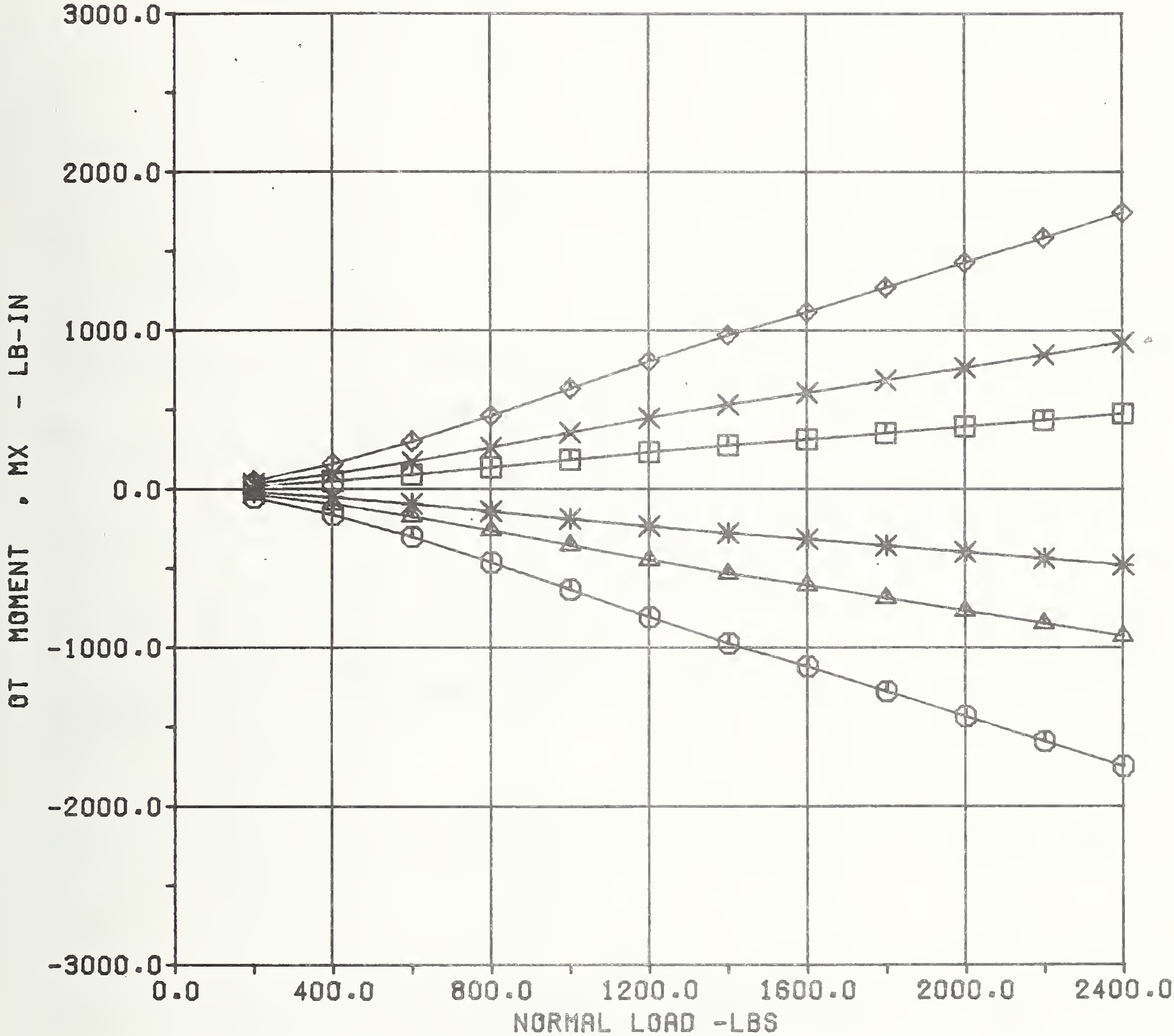
FIG. 11 OT MOMENT VS. NORMAL LOAD WITH SLIP ANGLE VARYING

(F78X14 GY BB CPCP CAMBER=0., SLIP=0.)



● SLIP ANGLE = -4.000 -DEGREES
▲ SLIP ANGLE = -2.000 -DEGREES
■ SLIP ANGLE = -1.000 -DEGREES
■ SLIP ANGLE = 1.000 -DEGREES
X SLIP ANGLE = 2.000 -DEGREES
◆ SLIP ANGLE = 4.000 -DEGREES

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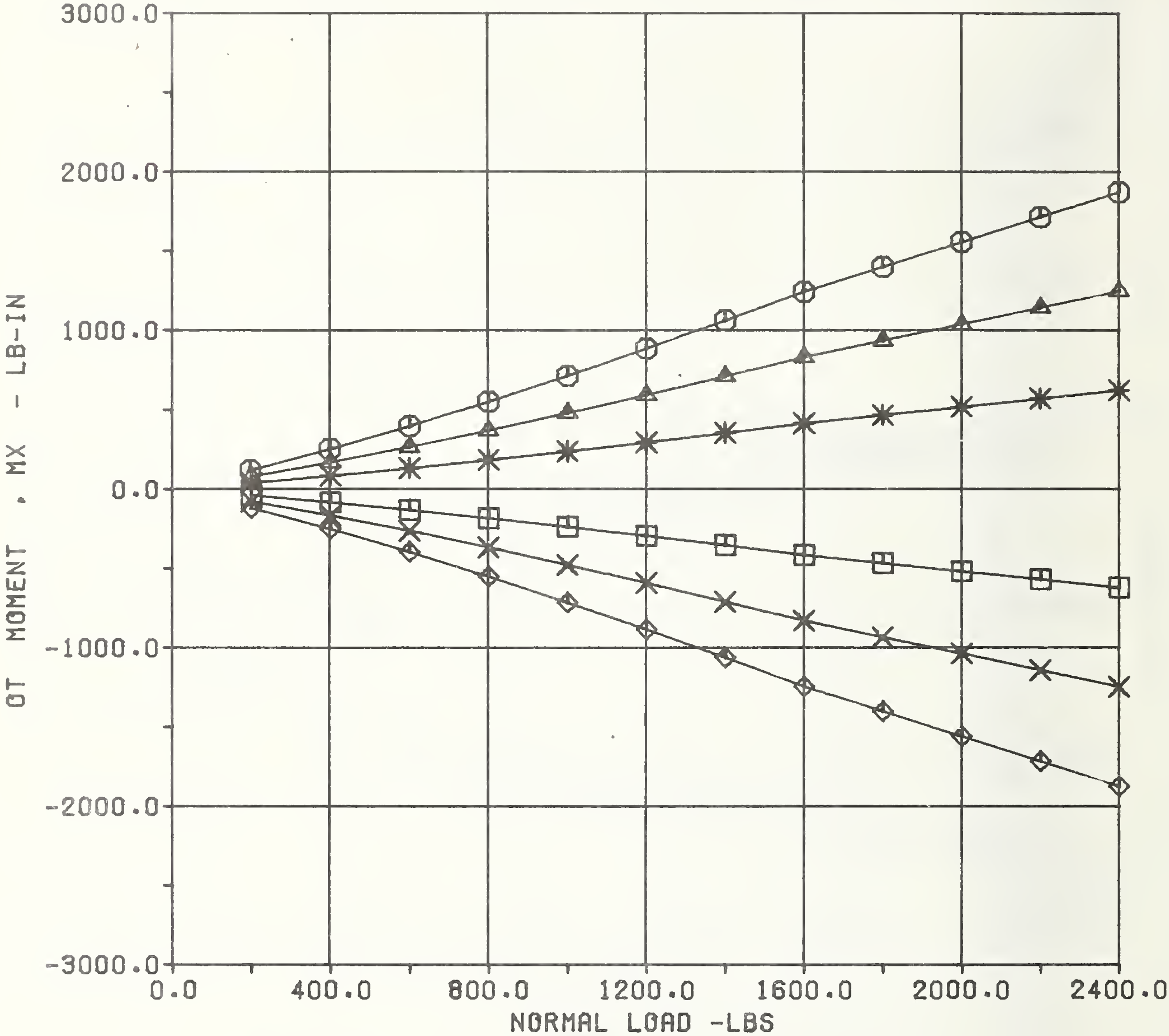
FIG. 12 OT MOMENT VS. NORMAL LOAD WITH CAMBER ANGLE VARYING

(F78X14 GY BB CPCP SLIP ANGLE=0., CAMBER=0.)



CAMBER ANGLE= -6.000 -DEGREES
CAMBER ANGLE= -4.000 -DEGREES
CAMBER ANGLE= -2.000 -DEGREES
CAMBER ANGLE= 2.000 -DEGREES
X CAMBER ANGLE= 4.000 -DEGREES
CAMBER ANGLE= 6.000 -DEGREES

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2. PRESENTED HERE IS A COPY OF THE INFORMATION AVAILABLE FROM REFERENCE 17 FOR A PARTICULAR TIRE. THE PARAMETERS FROM THIS DATA PACKET WERE USED TO GENERATE THE GRAPHS IN SECTION 1.

TIRE IDENTIFICATION

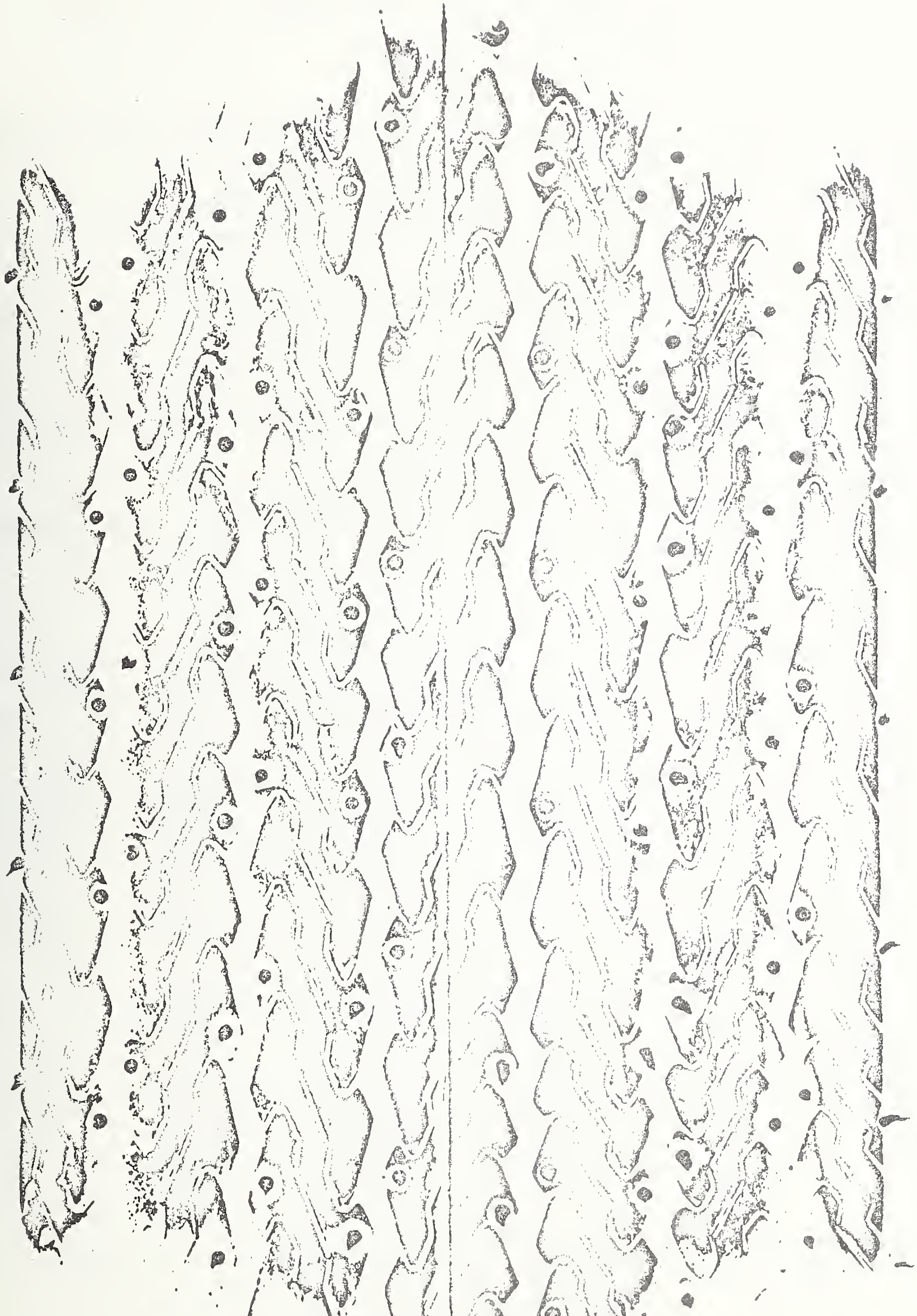
TIRF TIRE NUMBER		011
SIZE		F 78-14
MANUFACTURER (DISTRIBUTOR)		GY
BRAND NAME		CUSTOM POWER CUSHION POLYGLAS
LOAD RANGE (PLY RATING)		B
MAX T&RA LOAD, lb		1500
MAX INFL PRESS, psi		32
NO OF PLIES AND CORD MATERIAL	TREAD	2P + 2F
	SIDEWALL	2P
DOT NO		MP L7 DDA 333
CONSTRUCTION TYPE		BB
ASPECT RATIO, COMPUTED		76.8
T&RA RIM WIDTH		5.50
SHORE HARDNESS (STD VAR)		59.8 ( )
REMARKS		

NOTATIONS

BFG	GOODRICH
CO	COOPER
DA	DAYTON
DU	DUNLOP
FI	FIRESTONE
GT	GENERAL TIRE
GY	GOODYEAR
KS	KELLY SPRINGF'D
LE	LEE
MI	MICHELIN
PI	PIRELLI
SE	SEARS
UN	UNIROYAL
B	BIAS PLY
BB	BIAS BELTED
R	RADIAL PLY
F	FIBERGLAS
H	HIGH PERFORMANCE ORGANIC FIBER
N	NYLON
P	POLYESTER
R	RAYON
S	STEEL
TT	TUBETYPE
TL	TUBELESS

TIRF RUN IDENTIFICATION

RUN NO (0602-Series)		389	464
ROAD SPEED, mph		30	
WATER DEPTH, mil		—	
COLD INFL PRESS, psi		24	
100% DESIGN LOAD, lb		1280	
RIM WIDTH, in		5.50	
GROOVE DEPTH, %		100	
ROAD SKID NUMBER	DRY	85	
	WET	—	



TIRE No. 011

EAST

TIRE UNIFORMITY (SAE RECOMMENDED PRACTICE J332A)

TIRF TIRE NO		011
TEST LOAD at 28 psi, lb		1090
RADIAL FORCE VARIATION PEAK-TO-PEAK, lb	TOTAL	22
	FIRST HARMONIC	4
LATERAL FORCE VARIATION PEAK-TO-PEAK, lb	TOTAL	8
	FIRST HARMONIC	4
MEAN LATERAL FORCE, lb	FORWARD	-40
	REVERSE	+27
CONICITY, lb		-9
PLY STEER, lb		-33

CORNERING COEFFICIENTS

RUN: 389- 2- 6

CORNERING STIFFNESS, LB/RAD	A0	3318.89	
	A1	7.40	
	A2	2804.77	
CAMBER STIFFNESS, LB/RAD	A3	1.266	
	A4	6024.23	
PEAK LATERAL FRICTION COEFFICIENT, LB/LB	B3	1.143	
	B1	-2.848E-04	
	B4	4.342E-08	
OVERTURNING MOMENT, FT LB	C1	-1.162E-04	$-1.3944\ 10^{-3}$
	C2	-5.638E-05	$-6.7661\ 10^{-4}$
	C3	-0.446	-5.352
ALIGNING TORQUE, FT LB	K1	-2.445E-04	$-2.934\ 10^{-3}$
	K2	2.343E-04	$2.812\ 10^{-3}$
	K3	0.127	1.524

************************ TEST DATA ************************

LOAD LB	CALPHA LB/DEG	CA/FZ LB/DEG/LB	NALPHA FTLB/DEG	NA/FZ FTLB/DEG/LB	NA/CA FT
2234.8	119.6	0.054	51.6	0.023	0.432
1913.8	132.6	0.069	46.2	0.024	0.349
1595.0	144.2	0.090	40.0	0.025	0.277
1276.3	149.5	0.117	30.1	0.024	0.201
959.9	145.0	0.151	20.6	0.021	0.142
637.3	118.3	0.186	10.8	0.017	0.092

LOAD LB	CGAMMA LB/DEG	CG/FZ LB/DEG/LB	NGAMMA FTLB/DEG	NG/FZ FTLB/DEG/LB	NG/CG FT
2234.8	33.0	0.015	4.4	0.002	0.134
1913.8	28.1	0.015	4.0	0.002	0.142
1595.0	25.0	0.016	3.6	0.002	0.145
1276.3	22.4	0.017	3.5	0.003	0.158
959.9	20.6	0.021	3.6	0.004	0.172

LOAD LB	CG/CA	MUY PEAK	SA @ MUY PEAK DEG
2234.8	0.276	0.73	28.8
1913.8	0.212	0.74	21.5
1595.0	0.173	0.80	19.3
1276.3	0.150	0.86	18.4
959.9	0.142	0.91	17.1
637.3		0.98	-15.2

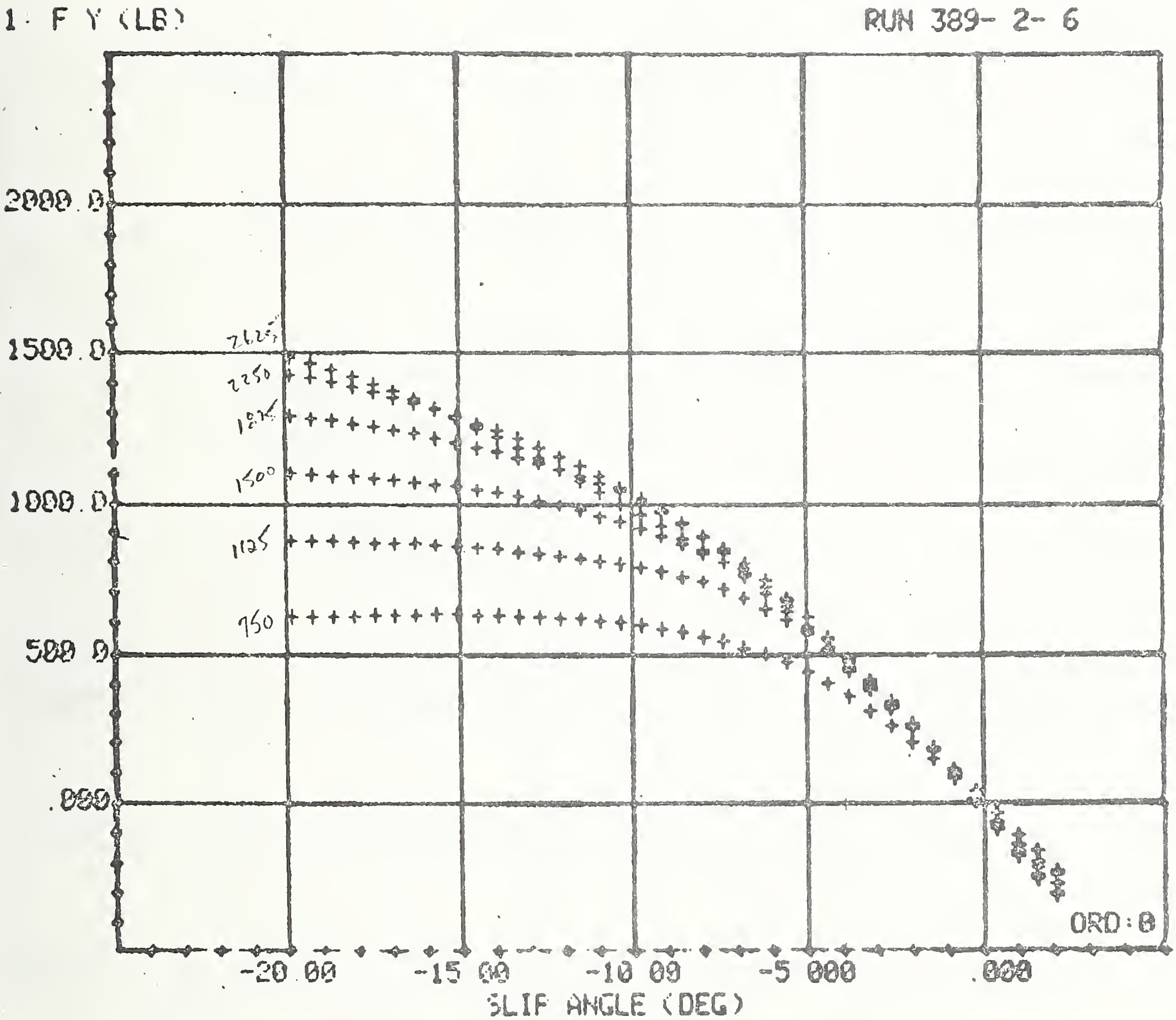
BRAKING COEFFICIENTS

RUN: 464- 2- 6

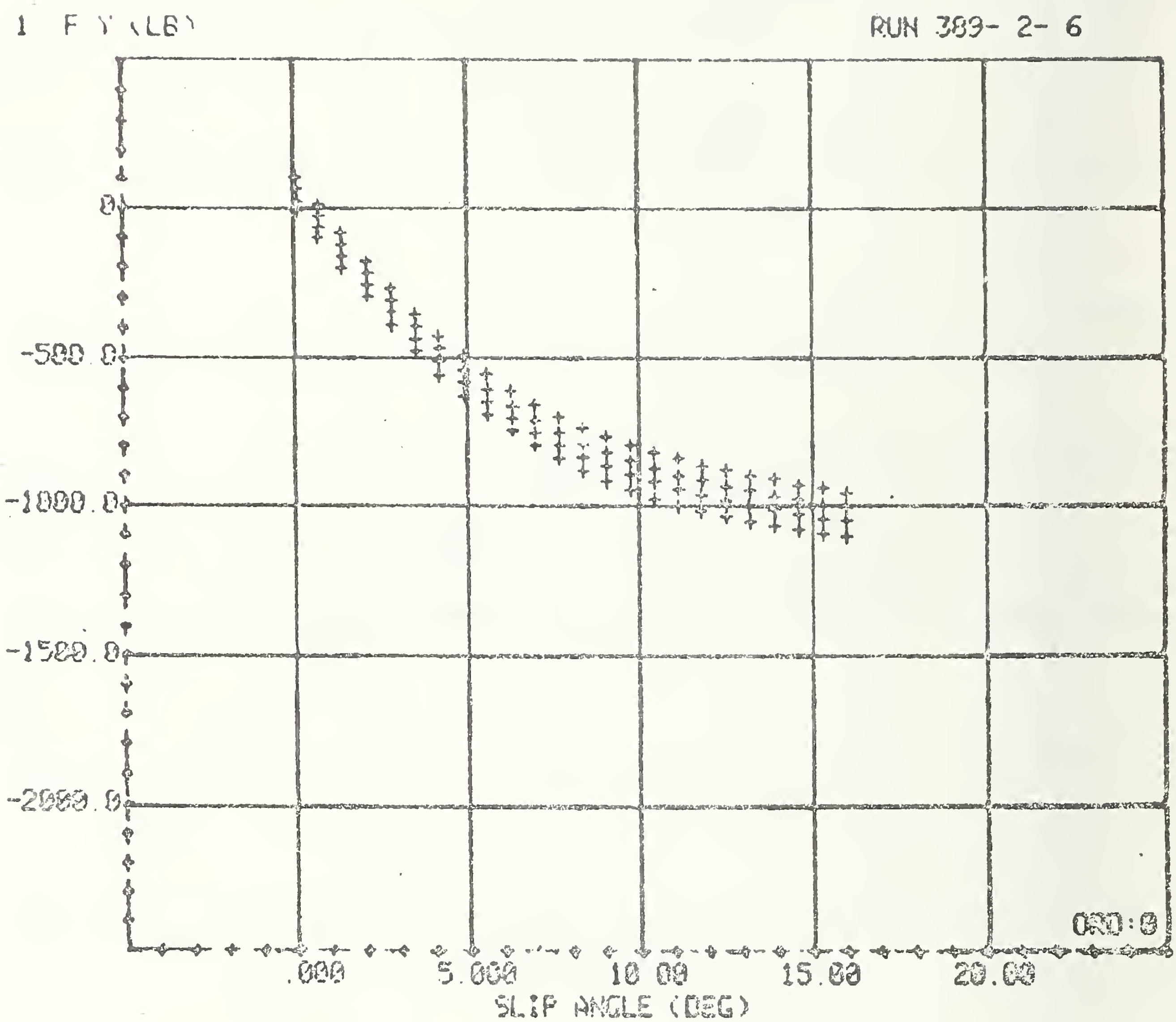
PEAK BRAKING COEFFICIENT, LB/LB			
	P0	1.0635	0.8879
	P1	-2.127E-04	3.651E-05
	P2		-8.913E-08
PEAK LONGITUDINAL SLIP			
	R0	-0.180	
	R1	-2.230E-06	
SLIDE BRAKING COEFFICIENT, LB/LB			
	S0	0.7873	0.9844
	S1	-1.257E-04	-4.221E-04
	S2		1.040E-07

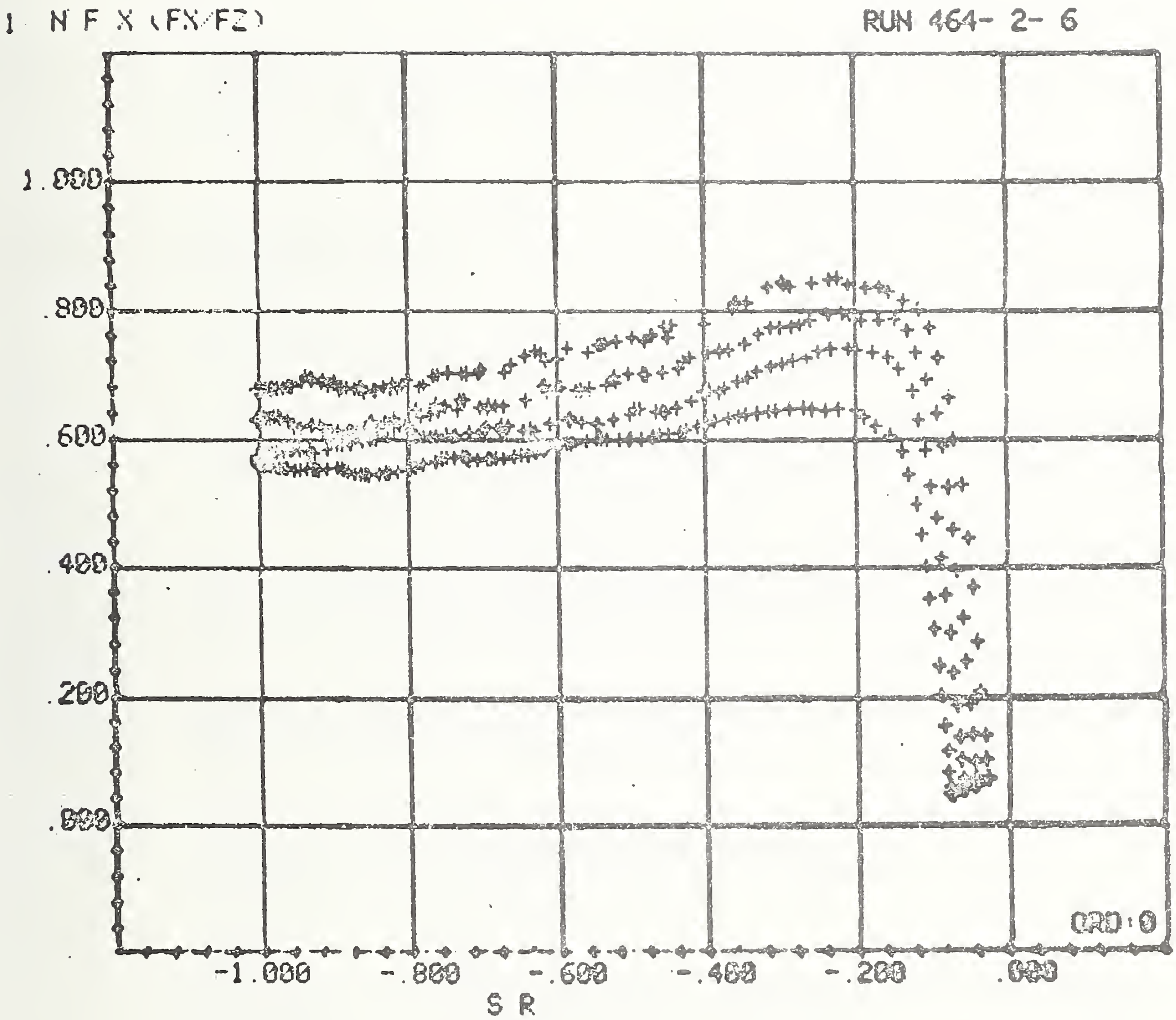
************************ TEST DATA ************************

LOAD LB	SL PEAK	MUX PEAK	MUX SLIDE	CS LB	CS/FZ LB/LB
1906.4	-0.196	0.647	0.562	20341.1	11.55
1589.0	-0.170	0.740	0.566	24428.9	16.43
1270.4	-0.172	0.797	0.628	25350.7	20.99
954.3	-0.193	0.853	0.674	17271.0	18.80



1· F Y (LB)
RUN 389- 2- 6
2000.0
1500.0
1000.0
500.0
.000
2625
2250
1875
1500
1125
750
ORD:0
-20.00
-15.00
-10.00
-5.000
.000
SLIP ANGLE (DEG)


1 F Y (LB)
RUN 389- 2- 6
0
-500.0
-1000.0
-1500.0
-2000.0
ORD:0
.000
5.000
10.00
15.00
20.00
SLIP ANGLE (DEG)


1 N F X (FX/FZ)
RUN 464- 2- 6
1.000
.800
.600
.400
.200
.000
ORD:0
-1.000
-.800
-.600
-.400
-.200
.000
S R

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